



Robert Mancini
Project Manager, Downstream
Chevron Environmental Management Company
1200 State Street
Perth Amboy, NJ 08861
Tel: (732) 738-2023
Fax: (732) 738-2039
RMancini@Chevron.com

July 23, 2020

Mr. Ricky Vargas
Land and Redevelopment Program Branch
Land, Chemicals and Redevelopment Division
United States Environmental Protection Agency, Region 2
290 Broadway, 25th Floor
New York, New York 10007

**Re: CAMU Closure IFC Drawings and CQA Plan
Former Chevron Perth Amboy Facility
Perth Amboy, New Jersey
SRP PI # 003621**

Dear Mr. Vargas:

Enclosed please find the Corrective Action Management Unit (CAMU) Closure Issued for Construction (IFC) Drawings and Construction Quality Assurance (CQA) Plan for reference. This CAMU Closure plan contains the design details necessary to complete construction of the CAMU Closure Cap in accordance with the approved CAMU Final Design Report.

If you require additional information regarding these CAMU Closure documents, please contact me at (732) 738-2023.

Sincerely,

A handwritten signature in black ink that reads "Robert Mancini". The signature is stylized with a large, sweeping flourish at the end.

Robert Mancini
Project Manager, Downstream

cc:
Mr. Charlie Zielinski – NJDEP

CCAMU Closure IFC Drawing and CQA Plan
Former Chevron Perth Amboy Facility, New Jersey
July 23, 2020

Enclosures (as described)

bcc: Ken Siet – TRC
Krista Manley – Buckeye Perth Amboy Terminal, LLC
Brendan Leehan – Buckeye Perth Amboy Terminal, LLC
Todd Frantz – Parsons

D-ID Number 2020-048-32

PARSONS

CHEVRON – PERTH AMBOY, NJ

CAMU CLOSURE

JUNE 2020

Table of Contents

IFC DRAWINGS

- G-001: TITLE PAGE
- C-001: EXISTING SITE CONDITIONS – AERIAL PHOTO
- C-002: EXISTING SITE CONDITIONS – TOPOGRAPHIC MAP
- C-006: TOP OF WASTE GRADING PLAN CELLS 1&2
- C-008: FINAL COVER GRADING PLAN
- C-009: CAMU EAST-WEST CROSS SECTION
- C-010: CAMU NORTH-SOUTH CROSS SECTIONS
- C-011: PERIMETER BERM CROSS SECTION EAST/WEST
- C-012: PERIMETER BERM CROSS SECTION NORTH/SOUTH
- C-020: FINAL COVER SYSTEM DETAILS 1
- C-021: FINAL COVER SYSTEM DETAILS 2
- C-025: POST-CLOSURE STORMWATER SYSTEM DETAILS
- C-026: PASSIVE GAS VENTING SYSTEM

CQA PLAN -REV 0

TECHNICAL SPECIFICATIONS

- 02100: SURVEYING -REV 1
- 02200: EARTHWORK – REV 1
- 02215: TRENCHING – REV 1
- 02235: GRAVEL – REV 1
- 02621: GEOCOMPOSITE – REV 0
- 02770: GEOMEMBRANE -REV 1
- 02790: INTERFACE FRICTION TESTING – REV 2

CHEVRON PERTH AMBOY FACILITY

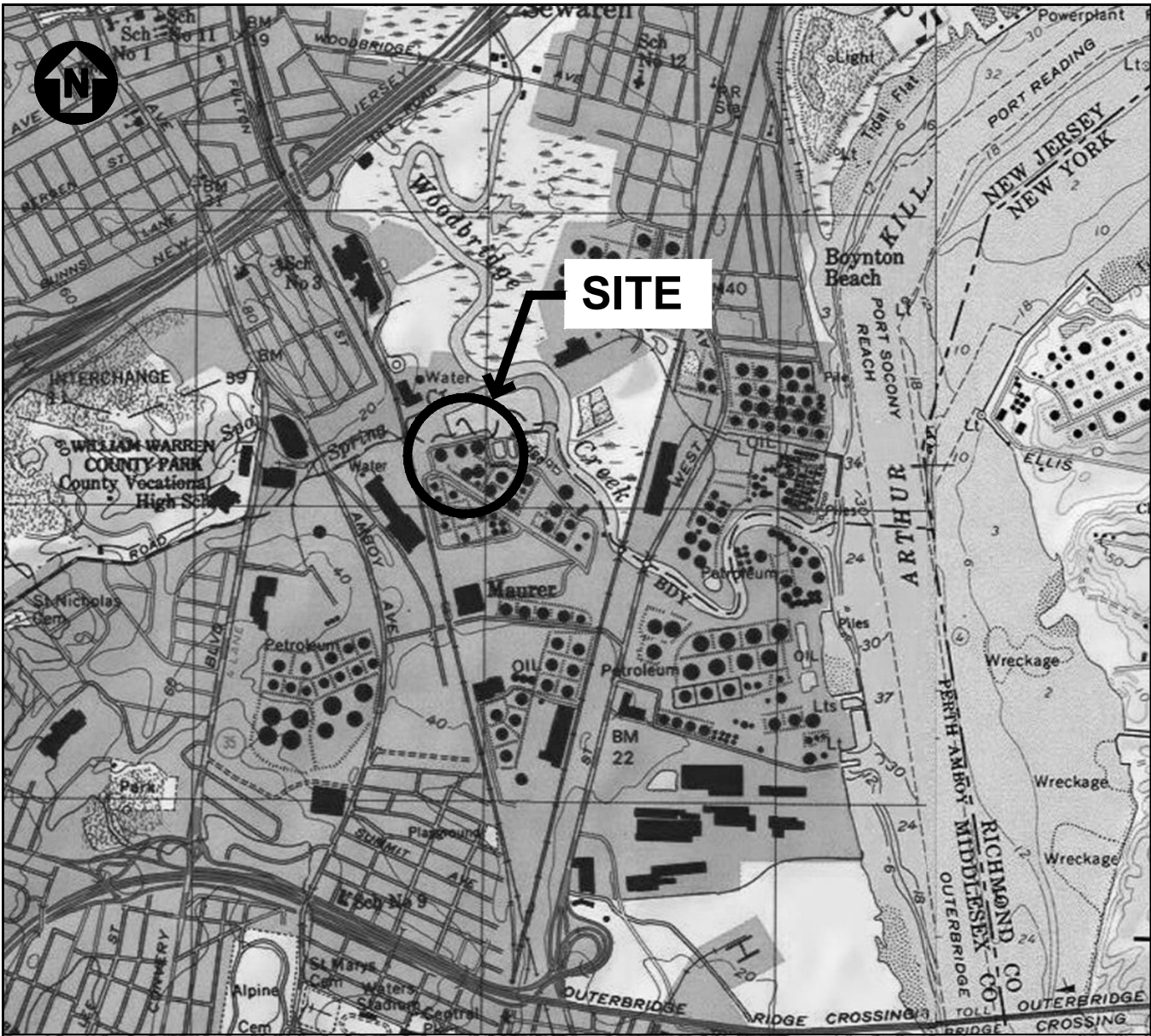
PERTH AMBOY, NEW JERSEY

CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)

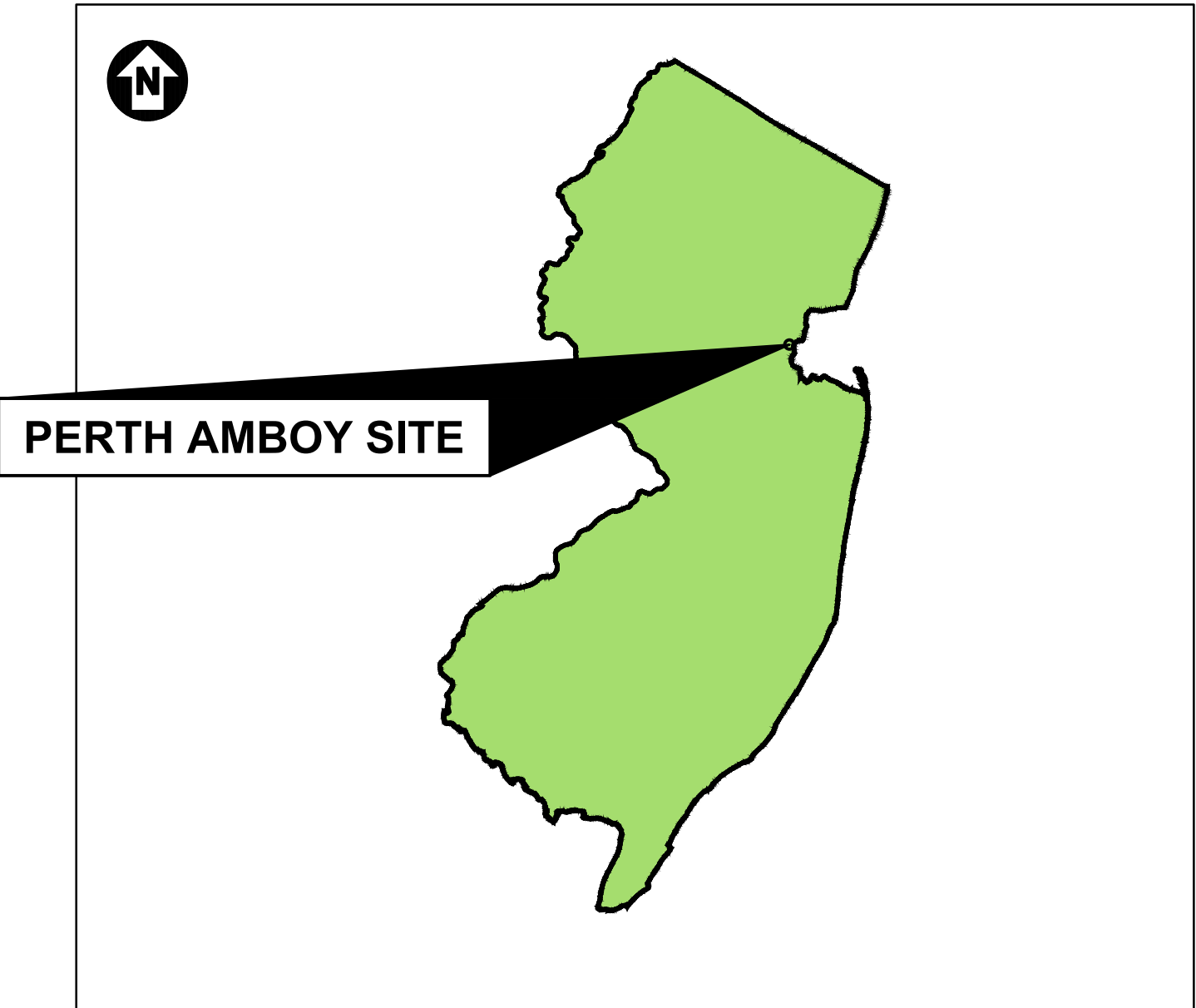
ISSUED FOR CONSTRUCTION DRAWINGS
MAY 2020

DRAWING INDEX

NUMBER	REV	TITLE
447218-G-001	1	TITLE SHEET
447218-C-001	0	EXISTING SITE CONDITIONS - AERIAL PHOTO
447218-C-002	0	EXISTING SITE CONDITIONS - TOPOGRAPHIC MAP
447218-C-006	0	TOP OF WASTE GRADING PLAN CELLS 1 & 2
447218-C-008	0	FINAL COVER GRADING PLAN
447218-C-009	0	CAMU EAST-WEST CROSS SECTION
447218-C-010	0	CAMU NORTH-SOUTH CROSS SECTIONS
447218-C-011	1	PERMINTER BERM CROSS SECTIONS- EAST/WEST
447218-C-012	1	PERIMETER BERM CROSS SECTIONS- NORTH/SOUTH
447218-C-020	0	FINAL COVER SYSTEM DETAILS 1
447218-C-021	0	FINAL COVER SYSTEM DETAILS 2
447218-C-025	0	POST-CLOSURE STORMWATER SYSTEM DETAILS
447218-C-026	1	PASSIVE GAS VENTING SYSTEM



SITE LOCATION MAP
NOT TO SCALE



STATE OF NEW JERSEY
NOT TO SCALE

DRAWING IS
HALF-SIZE IF
PLOTTED 11x17

NO.	REVISION	BY	APPR.	APPR.	APPR.	DATE	REFERENCE	DWG. NO.
0	ISSUED FOR CONSTRUCTION	M.S.	L.H.	M.F.	---	05/11/20		
1	UPDATED DWG NUMBERS AND REVISIONS	L.H.	M.F.	---	---	06/08/20		

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY
THIS DOCUMENT IS THE PROPERTY OF CHEVRON, PERTH AMBOY FACILITY PREPARED BY PARSONS, AND IS PROVIDED UPON THE CONDITION THAT IT WILL NEITHER BE REPRODUCED, COPIED, ISSUED TO A THIRD PARTY, WILL BE USED SOLELY FOR THE ORIGINAL INTENDED PURPOSE AND SOLELY FOR THE EXECUTION OR REVIEW OF THE ENGINEERING AND CONSTRUCTION OF THE PROJECT



CHEVRON
1200 STATE STREET
PERTH AMBOY, NJ 08861

JOB NO. 447218-03101 CERTIFICATE OF AUTHORIZATION NO. 24GA28098300	TITLE SHEET CAMU FINAL DESIGN
SCALE: AS SHOWN	
PARSONS 200 COTTONTAIL LANE SOMERSET, NJ 08873	JHG DRAWN LOCATION
	9/15/12 DATE
	AG CHK.
	10/27/12 DATE
	447218-G-001 REV 1



- LEGEND:
- HYDRANT
 - UTILITY POLE
 - BOLLARDS
 - SHRUBS AND BRUSH
 - VEGETATION SCRUB BRUSH
 - MARSH AREA
 - WATER PUDDLE
 - FENCE

NOTE:
AERIAL PHOTO PROVIDED BY PARSONS
BASED ON AERIAL SURVEY PERFORMED
IN MARCH 2020.

DRAWING IS
HALF-SIZE IF
PLOTTED 11x17

402004080

SCALE: 1"=40'

NO.	REVISION	BY	APPR.	APPR.	APPR.	CY	DATE	REFERENCE	DWG. NO.
0	ISSUED FOR CONSTRUCTION	M.S.	L.H.	M.F.	---	-	05/11/20		

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY

THIS DOCUMENT IS THE PROPERTY OF CHEVRON, PERTH AMBOY FACILITY PREPARED BY PARSONS, AND IS PROVIDED UPON THE CONDITION THAT IT WILL NEITHER BE REPRODUCED, COPIED, ISSUED TO A THIRD PARTY, WILL BE USED SOLELY FOR THE ORIGINAL INTENDED PURPOSE AND SOLELY FOR THE EXECUTION OR REVIEW OF THE ENGINEERING AND CONSTRUCTION OF THE PROJECT

Chevron

CHEVRON

1200 STATE STREET

PERTH AMBOY, NJ 08861

JHG

DATE

19/15/12

AG

10/27/12

200 COTTONTAIL LANE

SOMERSET, NJ 08873

EXISTING SITE CONDITIONS

AERIAL PHOTO

CAMU FINAL DESIGN

PARSONS

447218-C-001

0

JHG

DATE

19/15/12

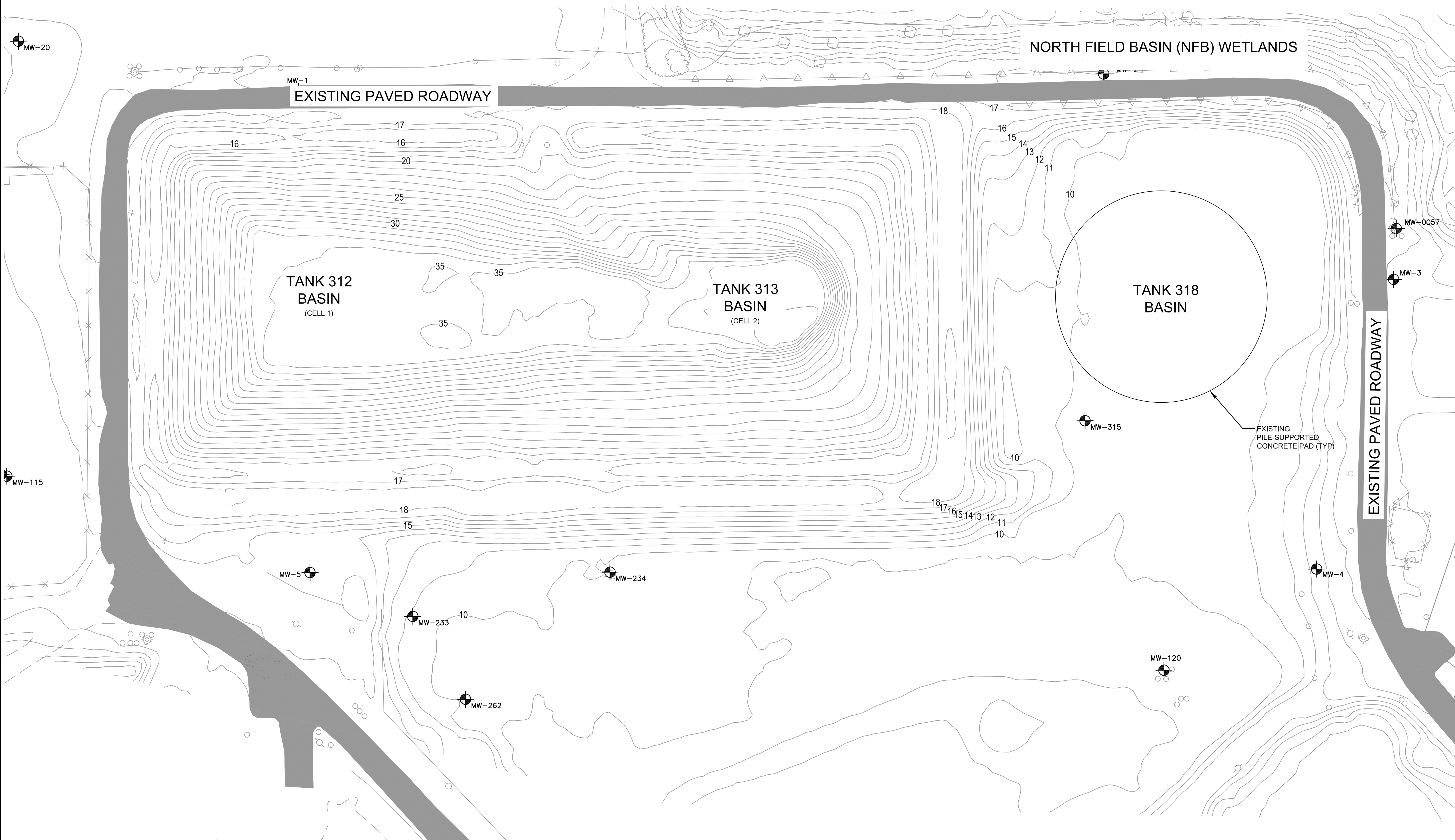
AG

10/27/12

SCALE: AS SHOWN

CERTIFICATE OF AUTHORIZATION NO. 246A26098300

JOB NO. 447218-03101



LEGEND:

- ×8.4 EXISTING GRADE SPOT ELEVATION
- EXISTING CONTOURS
- HYDRANT
- UTILITY POLE
- BOLLARDS
- SHRUBS AND BRUSH
- VEGETATION SCRUB BRUSH
- MARSH AREA
- WATER PUDDLE
- FENCE

NOTES:

- TOPOGRAPHIC MAP CREATED BY PARSONS, BASED ON AN AERIAL SURVEY PERFORMED IN MARCH 2020.
- MATERIAL ADDED TO CAMU AFTER SURVEY WAS TAKEN IS NOT SHOWN. ADDED MATERIAL TO BE PLACED IN CELL 2 AND GRADED AS SHOWN ON C-006.
- HORIZONTAL DATUM IS THE NEW JERSEY STATE PLANE COORDINATE SYSTEM (NAD83).
- VERTICAL DATUM IS THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29).

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY
THIS DOCUMENT IS THE PROPERTY OF CHEVRON, PERTH AMBOY FACILITY PREPARED BY PARSONS, AND IS PROVIDED UPON THE CONDITION THAT IT WILL NEITHER BE REPRODUCED, COPIED, ISSUED TO A THIRD PARTY, WILL BE USED SOLELY FOR THE ORIGINAL INTENDED PURPOSE AND SOLELY FOR THE EXECUTION OR REVIEW OF THE ENGINEERING AND CONSTRUCTION OF THE PROJECT



CHEVRON
1200 STATE STREET
PERTH AMBOY, NJ 08861

JOB NO. 447218-03101
CERTIFICATE OF AUTHORIZATION NO. 246A28098300

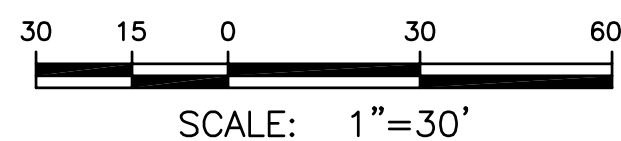
EXISTING SITE CONDITIONS
TOPOGRAPHIC MAP
CAMU FINAL DESIGN

SCALE: AS SHOWN

PARSONS
200 COTTONTAIL LANE
SOMERSET, NJ 08873

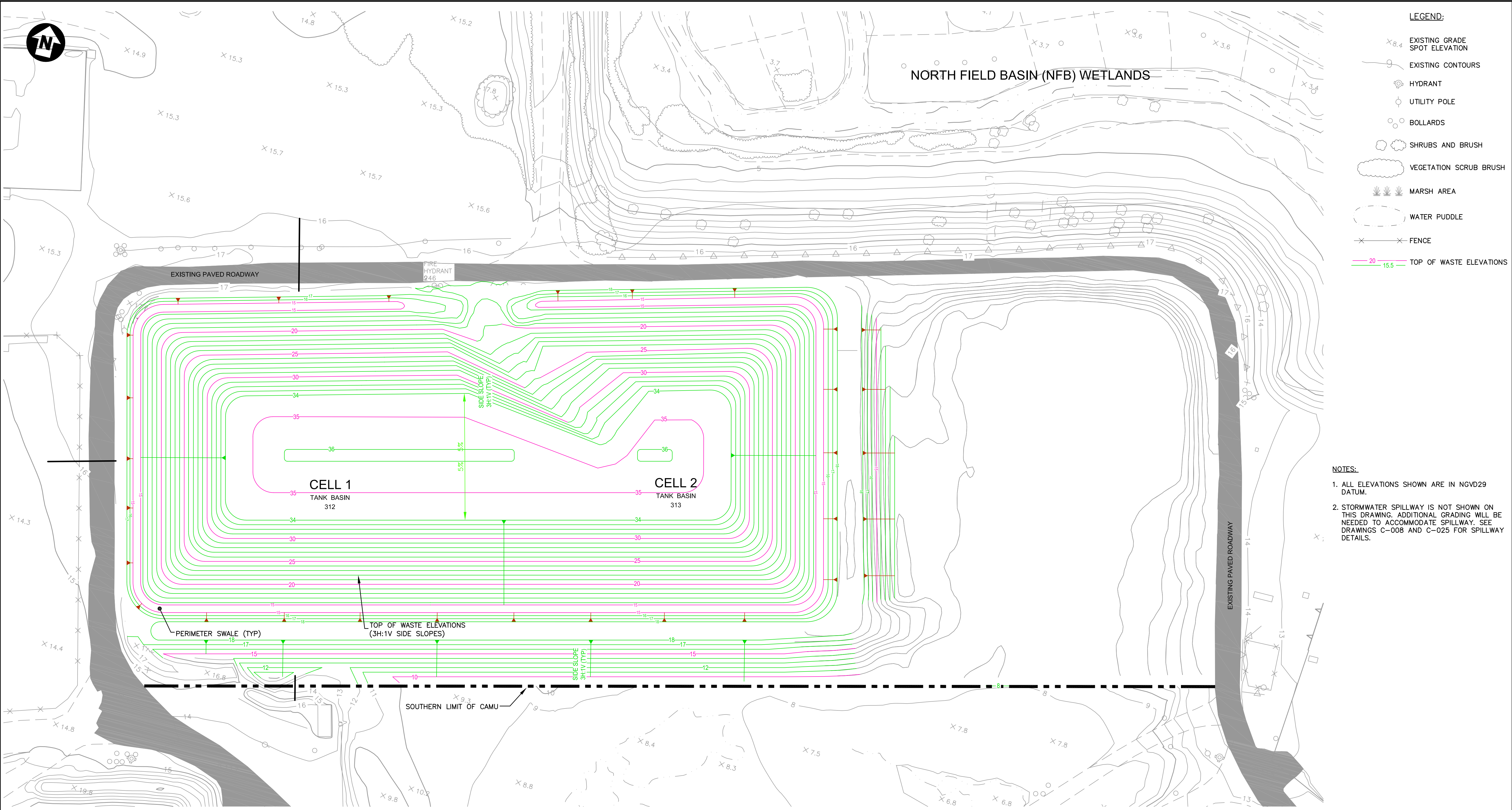
JHG	9/15/12	AG	10/27/12
DRAWN	DATE	CHK.	DATE
LOCATION	447218-C-002	REV	0

DRAWING IS
HALF-SIZE IF
PLOTTED 11x17



NO.	REVISION	BY	APPR.	APPR.	APPR.	CY	DATE
0	ISSUED FOR CONSTRUCTION	M.S.	L.H.	M.F.	---	-	05/11/20

REFERENCE	DWG. NO.



LEGEND:

- EXISTING GRADE SPOT ELEVATION
- EXISTING CONTOURS
- HYDRANT
- UTILITY POLE
- BOLLARDS
- SHRUBS AND BRUSH
- VEGETATION SCRUB BRUSH
- MARSH AREA
- WATER PUDDLE
- FENCE
- TOP OF WASTE ELEVATIONS

NOTES:

- ALL ELEVATIONS SHOWN ARE IN NGVD29 DATUM.
- STORMWATER SPILLWAY IS NOT SHOWN ON THIS DRAWING. ADDITIONAL GRADING WILL BE NEEDED TO ACCOMMODATE SPILLWAY. SEE DRAWINGS C-008 AND C-025 FOR SPILLWAY DETAILS.

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY
THIS DOCUMENT IS THE PROPERTY OF CHEVRON, PERTH AMBOY FACILITY PREPARED BY PARSONS, AND IS PROVIDED UPON THE CONDITION THAT IT WILL NEITHER BE REPRODUCED, COPIED, ISSUED TO A THIRD PARTY, WILL BE USED SOLELY FOR THE ORIGINAL INTENDED PURPOSE AND SOLELY FOR THE EXECUTION OR REVIEW OF THE ENGINEERING AND CONSTRUCTION OF THE PROJECT



CHEVRON
1200 STATE STREET
PERTH AMBOY, NJ 08861

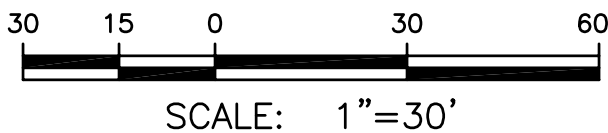
JOB NO. 447218-03101
CERTIFICATE OF AUTHORIZATION
NO. 246A28098300
SCALE: AS SHOWN

TOP OF WASTE GRADING PLAN
CELLS 1 & 2
CAMU FINAL DESIGN

PARSONS
200 COTTONTAIL LANE
SOMERSET, NJ 08873

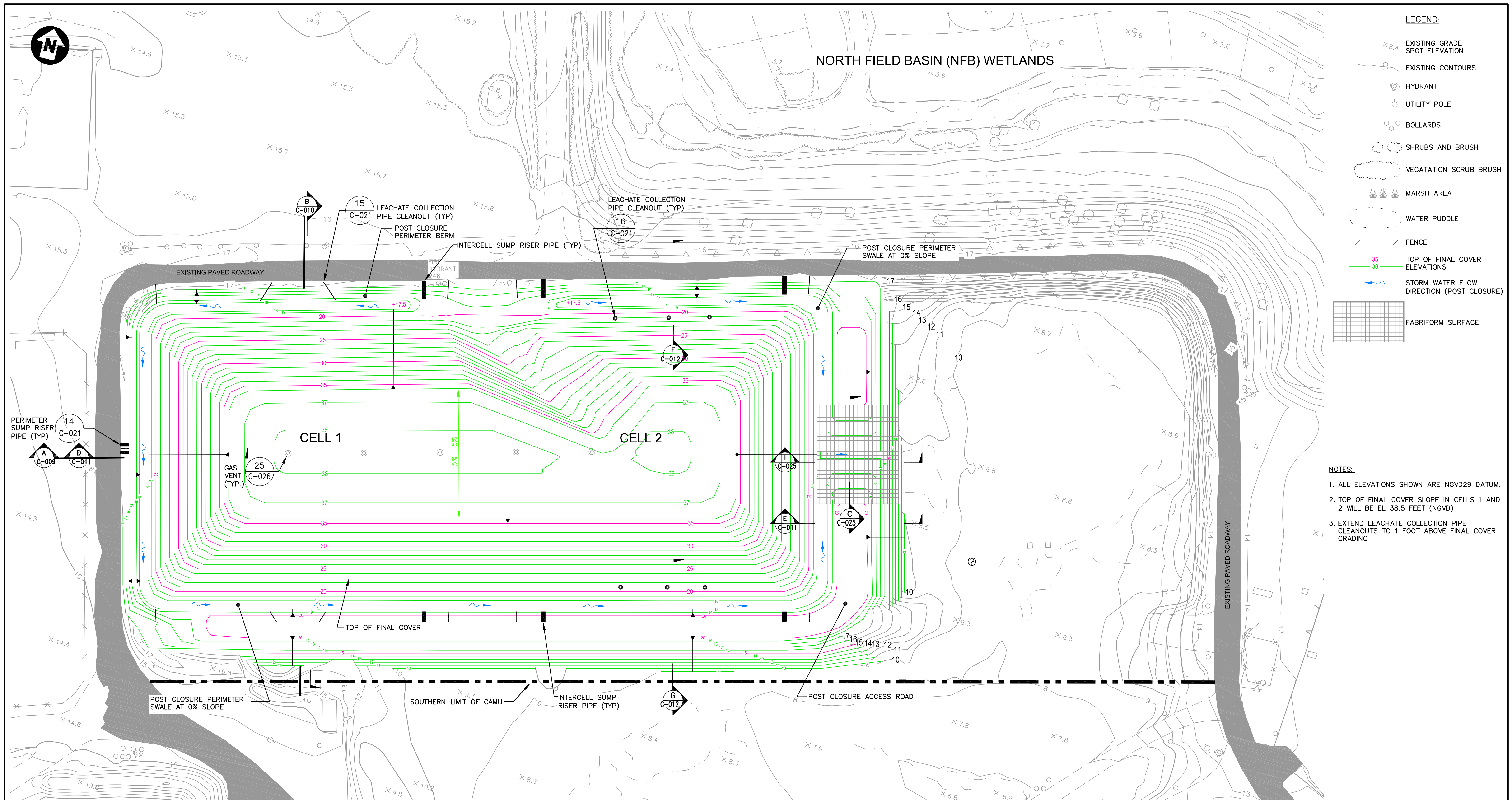
JHG	9/15/12	AG	10/27/12
DRAWN	DATE	CHK.	DATE
LOCATION	447218-C-006	REV	0

DRAWING IS
HALF-SIZE IF
PLOTTED 11x17



NO.	REVISION	BY	APPR.	APPR.	APPR.	CY	DATE
0	ISSUED FOR CONSTRUCTION	M.S.	L.H.	M.F.	---	-	05/11/20


REFERENCE	DWG. NO.



30 15 0 30 60

SCALE: 1"=30'

[illegible]



CHEVRON

1200 STATE STREET
PERTH AMBOY, NJ 08861


JOB NO. 447218-03101

CERTIFICATE OF AUTHORIZATION
NO. 24GAZ8098300

SCALE: AS SHOWN

FINAL COVER GRADING PLAN

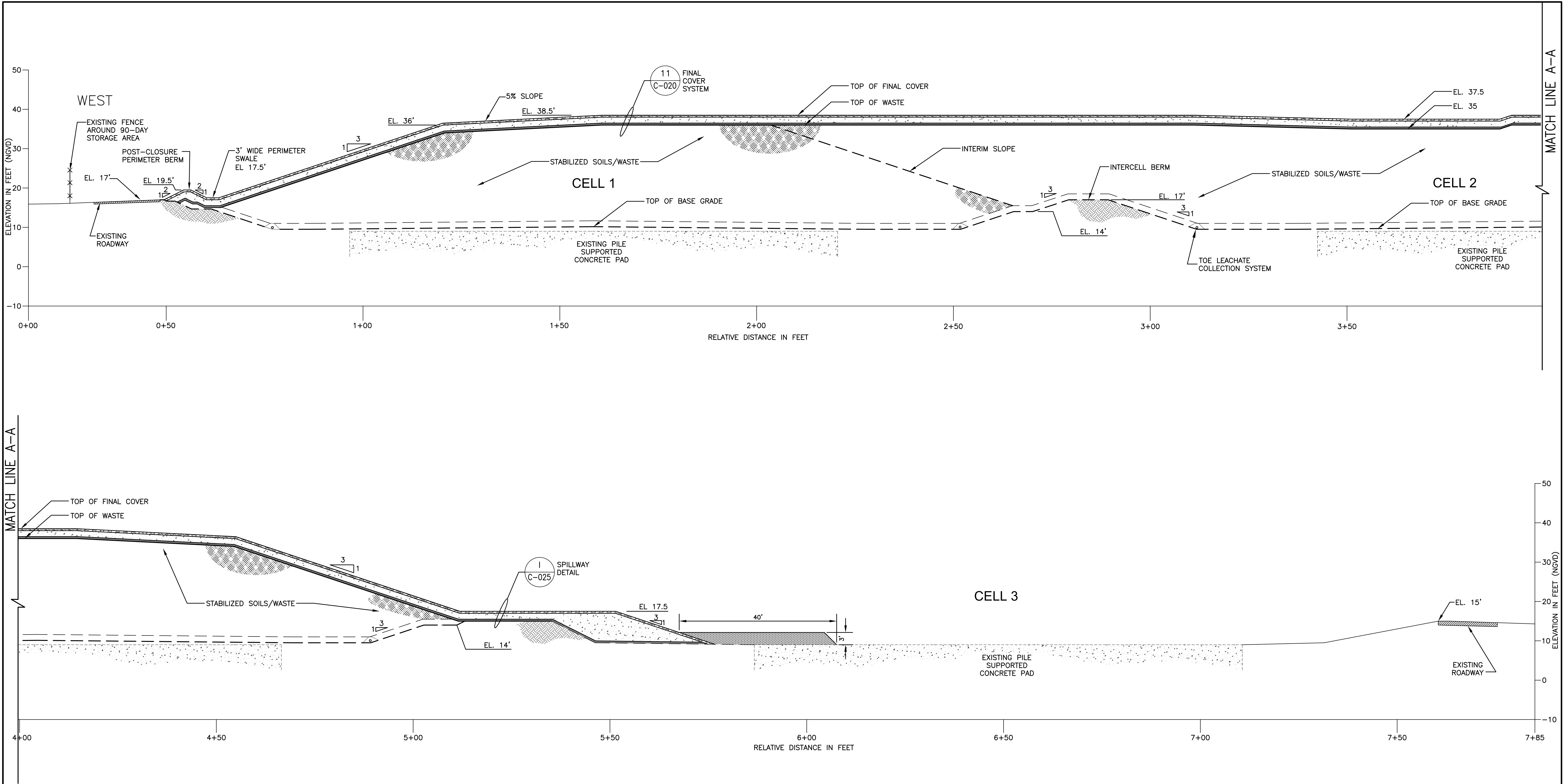
CAMU FINAL DESIGN



PARSONS

200 COTTONTAIL LANE
SOMERSET, NJ 08873

JHG	9/15/12	AG	10/27/12
DRAWN	DATE	CHK.	DATE
LOCATION	447218-C-008		
	REV 0		

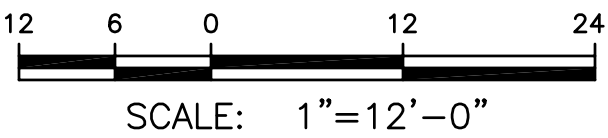


NOTES:

1. ALL ELEVATIONS SHOWN ARE IN NGVD29 DATUM.
2. WASTE WILL BE RAISED TO TOP EL 36 FEET (NGVD) IN CELLS 1 AND 2.
3. TOP OF FINAL COVER ELEVATION IN CELLS 1 AND 2 WILL BE 38.5 FEET (NGVD).
4. IN SWALE AND BERM AREA EXCAVATE DOWN TO REQUIRED GRADE AND PLACE A 6 INCH LEVELING LAYER OF SOIL AND FILL THE REMAINING AREA WITH SOIL COVER MATERIAL TO REQUIRED ELEVATIONS.

A EAST-WEST CROSS SECTION FOR CELLS 1 THROUGH 3
C-008 SCALE: 1"=12'-0"

DRAWING IS
HALF-SIZE IF
PLOTTED 11x17



NO.	REVISION	BY	APPR.	APPR.	APPR.	CY	DATE
0	ISSUED FOR CONSTRUCTION	M.S.	L.H.	M.F.	---	-	05/11/20

REFERENCE	DWG. NO.

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY
THIS DOCUMENT IS THE PROPERTY OF CHEVRON, PERTH AMBOY FACILITY PREPARED BY PARSONS, AND IS PROVIDED UPON THE CONDITION THAT IT WILL NEITHER BE REPRODUCED, COPIED, ISSUED TO A THIRD PARTY, WILL BE USED SOLELY FOR THE ORIGINAL INTENDED PURPOSE AND SOLELY FOR THE EXECUTION OR REVIEW OF THE ENGINEERING AND CONSTRUCTION OF THE PROJECT



CHEVRON
1200 STATE STREET
PERTH AMBOY, NJ 08861

JOB NO. 447218-03101
CERTIFICATE OF AUTHORIZATION
NO. 246A28098300

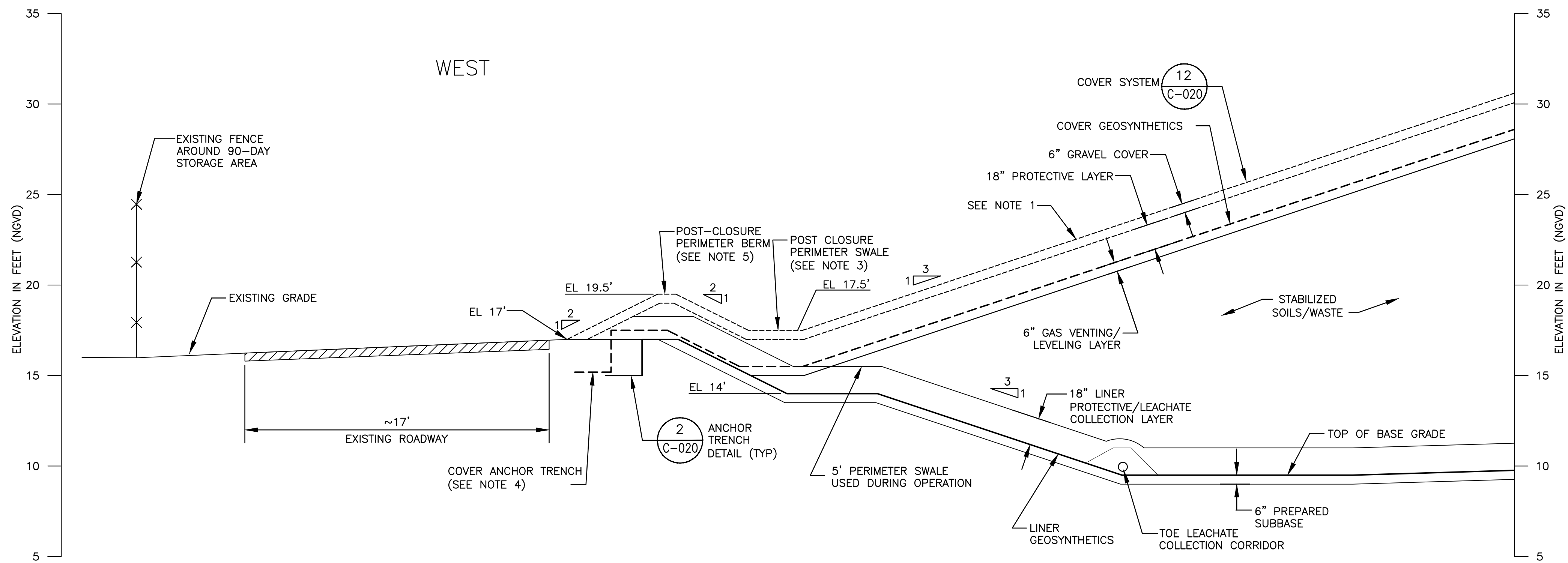
CAMU EAST-WEST CROSS SECTION

SCALE: AS SHOWN

CAMU FINAL DESIGN

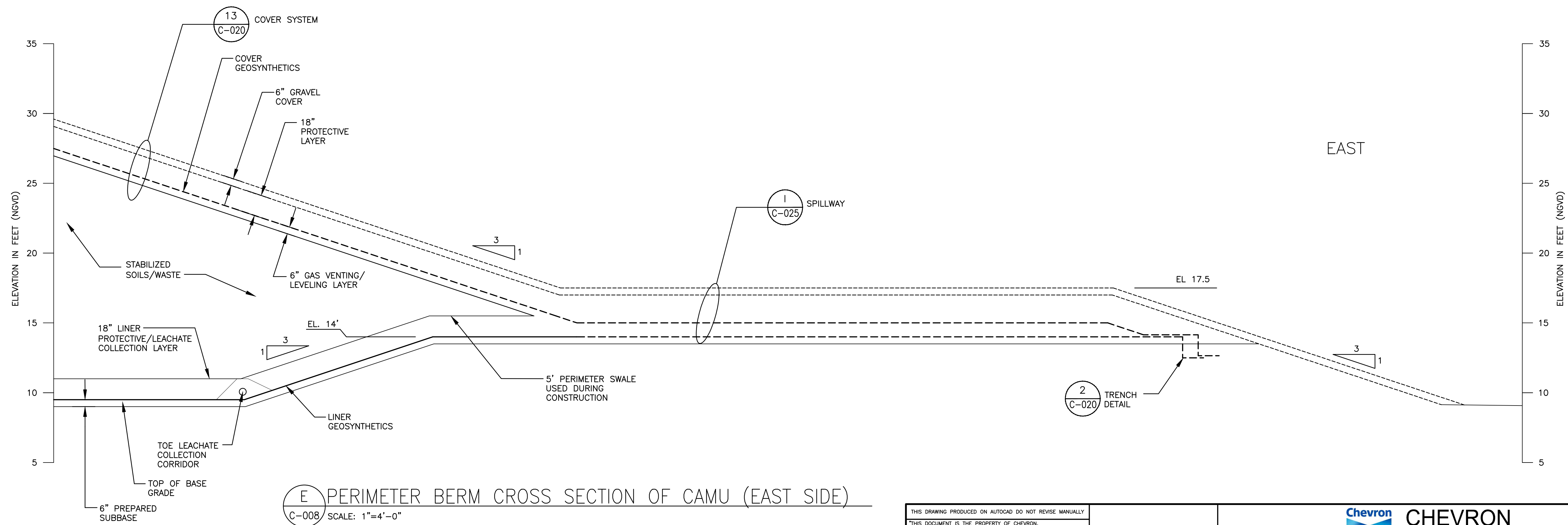
PARSONS
200 COTTONTAIL LANE
SOMERSET, NJ 08873

JHG	9/15/12	AG	10/27/12
DRAWN	DATE	CHK.	DATE
LOCATION			
447218-C-009			REV 0



D PERIMETER BERM CROSS SECTION OF CAMU (WEST SIDE)
C-008 SCALE: 1"=4'-0"

- NOTES:
1. SOLID LINES INDICATE CONSTRUCTION THAT WAS PERFORMED AS PART OF CELL CONSTRUCTION. DASHED LINES INDICATE CONSTRUCTION THAT WILL BE PERFORMED AS PART OF FINAL CLOSURE.
 2. AFTER CLOSURE OF CAMU CELLS, STORM WATER WILL BE MANAGED USING A 3-FT WIDE PERIMETER SWALE WITH A 0% BOTTOM SLOPE AND A 2-FT DEPTH. THE INVERT ELEVATION OF SWALE WILL BE AT INVERT EL 17.5 FT (NGVD).
 3. GEOMEMBRANE IN FINAL COVER SYSTEM WILL BE ANCHORED IN AN INDEPENDENT ANCHOR TRENCH AS SHOWN TO COMPLETELY ENCAPSULATE THE WASTE DISPOSED IN CELLS.
 4. POST-CLOSURE PERIMETER BERM WILL BE CONSTRUCTED AS PART OF CLOSURE. THE WIDTH AND CREST ELEVATION OF BERM VARIES.
 5. GENERAL FILL SHALL BE THE SAME AS SUBBASE FILL SPECIFIED IN SPECIFICATION 02200.

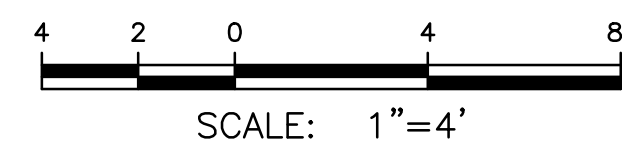


E PERIMETER BERM CROSS SECTION OF CAMU (EAST SIDE)
C-008 SCALE: 1"=4'-0"

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY
THIS DOCUMENT IS THE PROPERTY OF CHEVRON, PERTH AMBOY FACILITY PREPARED BY PARSONS, AND IS PROVIDED UPON THE CONDITION THAT IT WILL NEITHER BE REPRODUCED, COPIED, ISSUED TO A THIRD PARTY, WILL BE USED SOLELY FOR THE ORIGINAL INTENDED PURPOSE AND SOLELY FOR THE EXECUTION OR REVIEW OF THE ENGINEERING AND CONSTRUCTION OF THE PROJECT

NO.	REVISION	BY	APPR.	APPR.	APPR.	DATE	REFERENCE	DWG. NO.
0	ISSUED FOR CONSTRUCTION	M.S.	L.H.	M.F.	---	05/11/20		
1	UPDATED DWG TITLE	L.H.	M.F.	---	---	06/08/20		

DRAWING IS
HALF-SIZE IF
PLOTTED 11x17



CHEVRON
1200 STATE STREET
PERTH AMBOY, NJ 08861

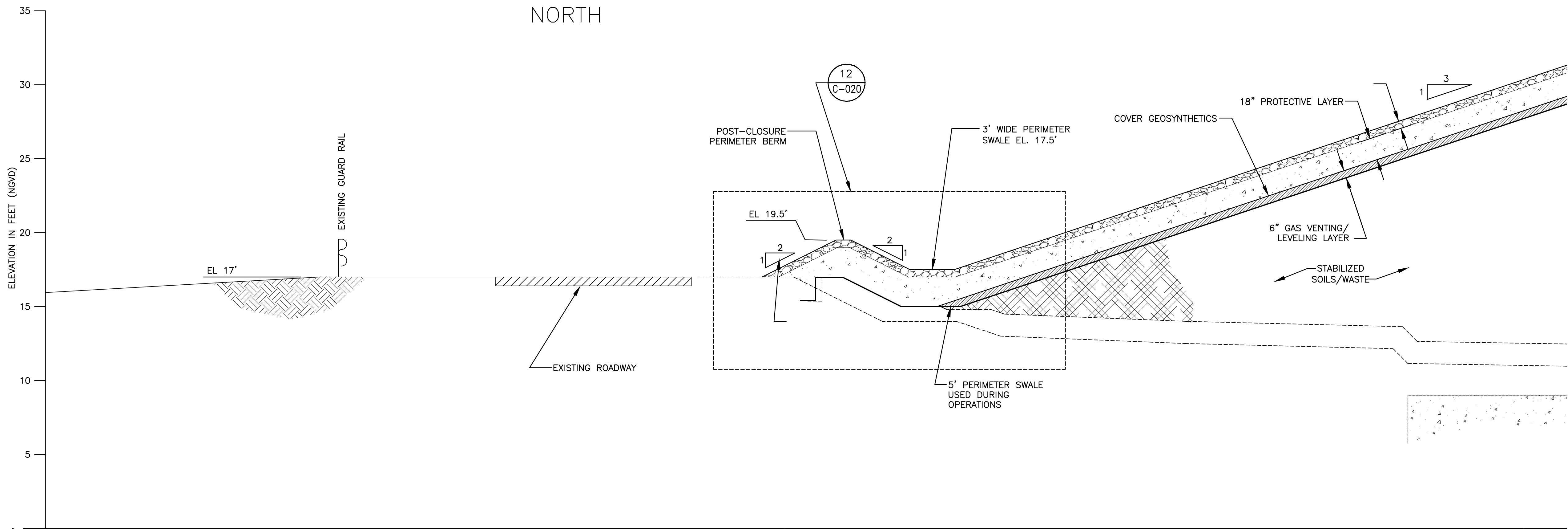
**PERIMETER BERM
CROSS SECTIONS - EAST/WEST**
CAMU FINAL DESIGN

PARSONS
200 COTTONTAIL LANE
SOMERSET, NJ 08873

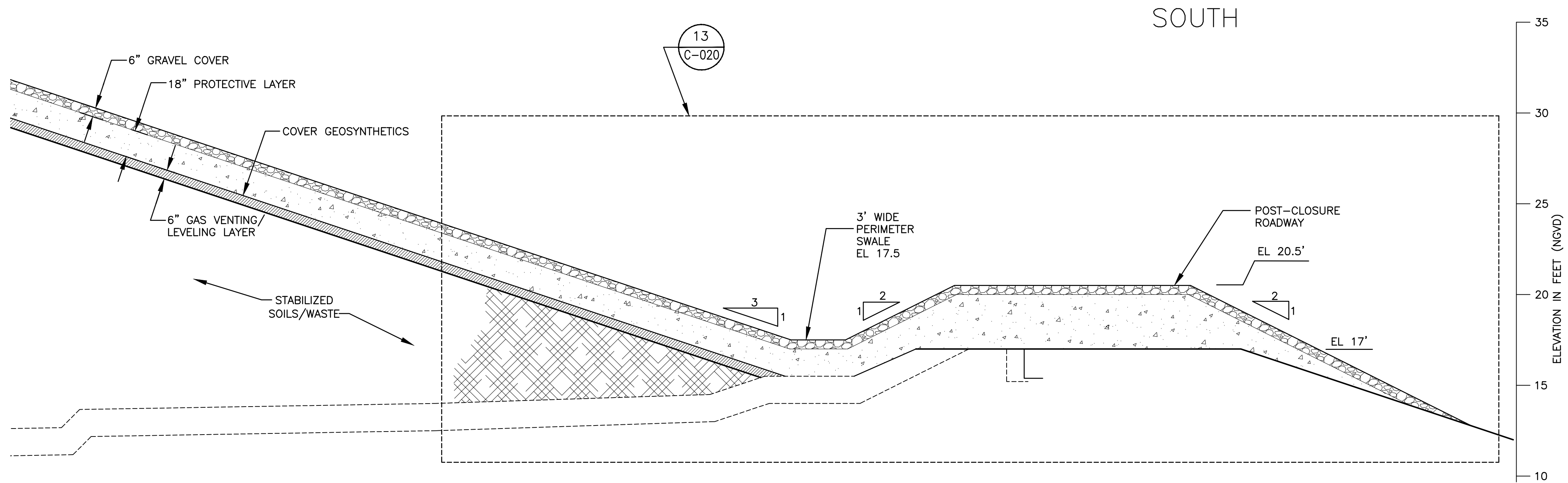
JHG	9/15/12	AG	10/27/12
DRAWN	DATE	CHK.	DATE
LOCATION			

447218-C-011	REV 1
--------------	-------

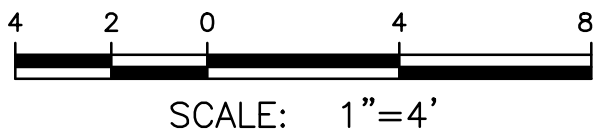
JOB NO. 447218-03101
CERTIFICATE OF AUTHORIZATION
NO. 24GA28098300
SCALE: AS SHOWN



- NOTES:
1. SOLID LINES INDICATE CONSTRUCTION THAT WAS PERFORMED AS PART OF CELL CONSTRUCTION. DASHED LINES INDICATE CONSTRUCTION THAT WILL BE PERFORMED AS PART OF FINAL CLOSURE.
 2. AFTER CLOSURE OF CAMU CELLS, STORM WATER WILL BE MANAGED USING A 3-FEET WIDE PERIMETER SWALE WITH A 0% BOTTOM SLOPE AND A 2-FEET DEPTH. THE INVERT ELEVATION OF SWALE WILL BE 17.5 FT.
 3. GEOMEMBRANE IN FINAL COVER SYSTEM WILL BE ANCHORED IN AN INDEPENDENT ANCHOR TRENCH AS SHOWN TO COMPLETELY ENCAPSULATE THE WASTE DISPOSED IN CELLS.



DRAWING IS
HALF-SIZE IF
PLOTTED 11x17



NO.	REVISION	BY	APPR.	APPR.	APPR.	DATE
0	ISSUED FOR CONSTRUCTION	M.S.	L.H.	M.F.	---	05/11/20
1	UPDATED DWG NAME	L.H.	M.F.	---	---	06/08/20

REFERENCE	DWG. NO.

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY

THIS DOCUMENT IS THE PROPERTY OF CHEVRON, PERTH AMBOY FACILITY PREPARED BY PARSONS, AND IS PROVIDED UPON THE CONDITION THAT IT WILL NEITHER BE REPRODUCED, COPIED, ISSUED TO A THIRD PARTY, WILL BE USED SOLELY FOR THE ORIGINAL INTENDED PURPOSE AND SOLELY FOR THE EXECUTION OR REVIEW OF THE ENGINEERING AND CONSTRUCTION OF THE PROJECT



CHEVRON
1200 STATE STREET
PERTH AMBOY, NJ 08861

JOB NO. 447218-03101

CERTIFICATE OF AUTHORIZATION
NO. 24GA28098300

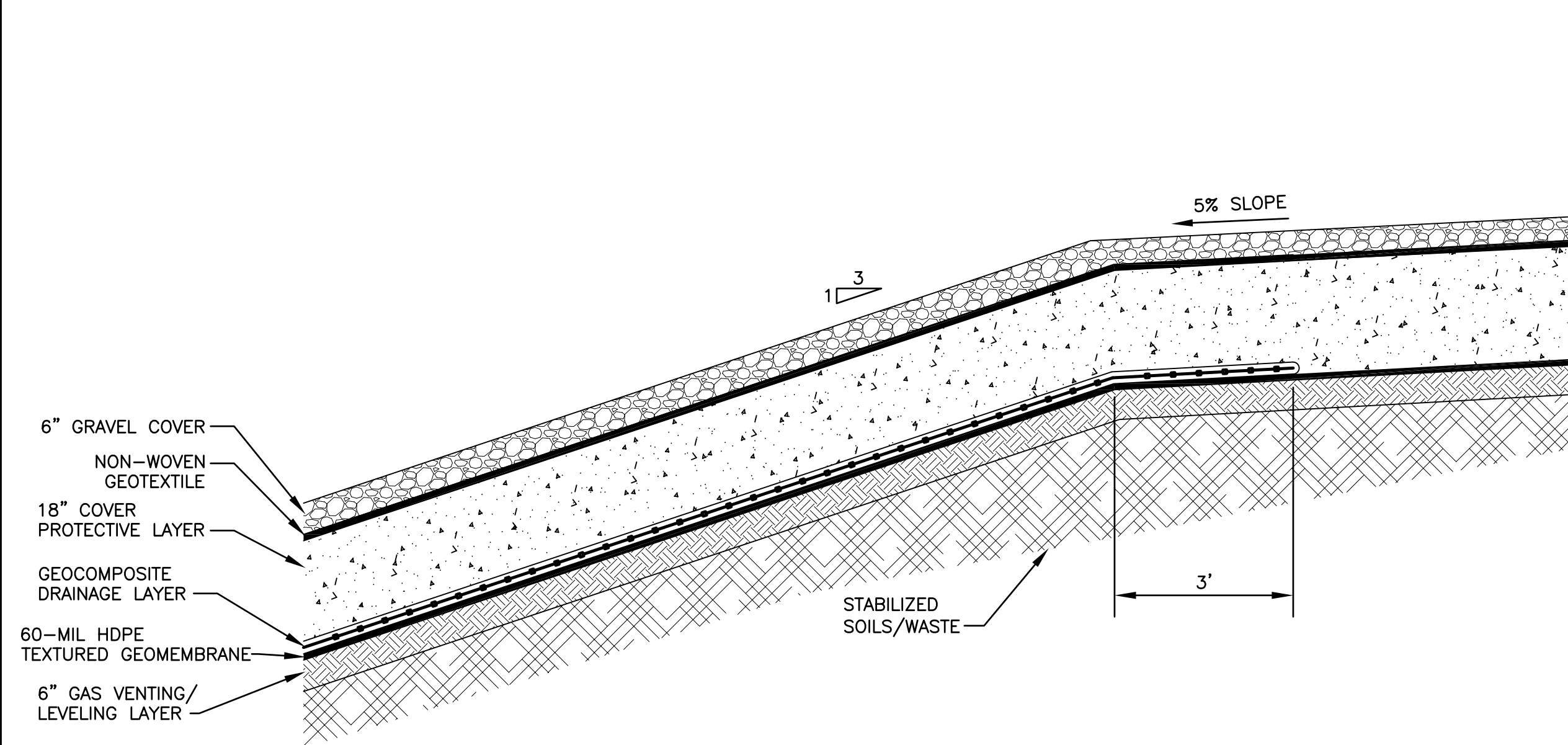
SCALE: AS SHOWN

PARSONS
200 COTTONTAIL LANE
SOMERSET, NJ 08873

**PERIMETER BERM
CROSS SECTIONS - NORTH/SOUTH**

CAMU FINAL DESIGN

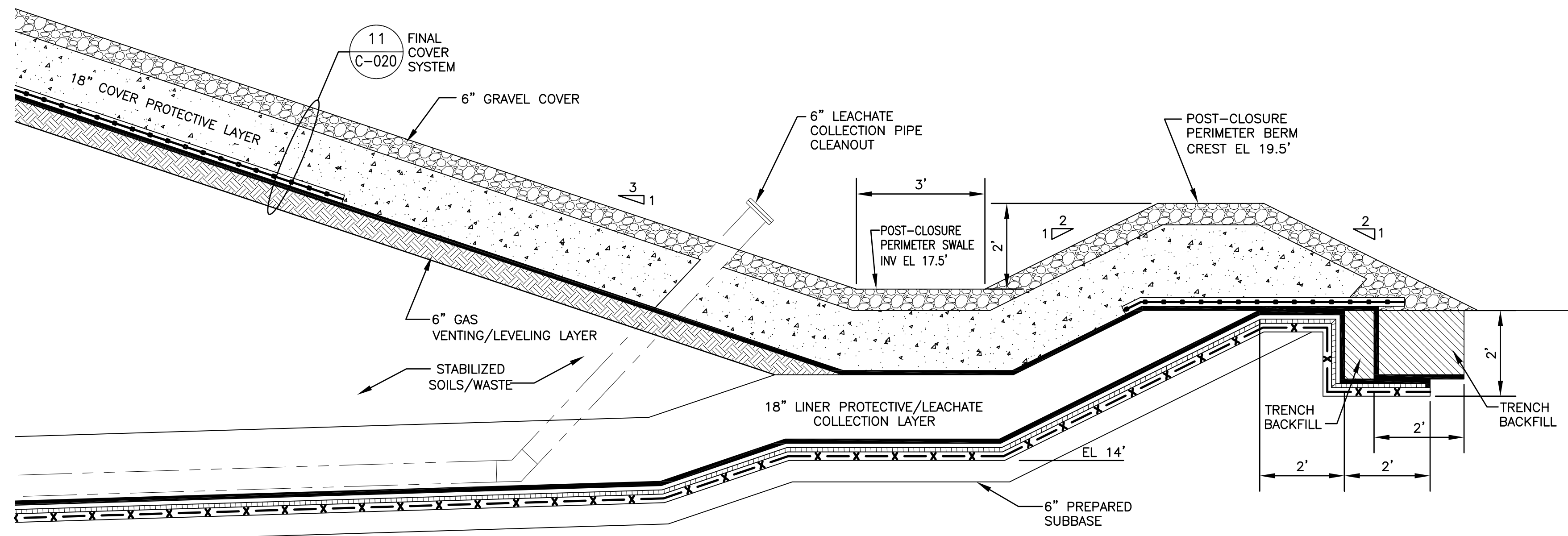
JHG	9/15/12	AG	10/27/12
DRAWN	DATE	CHK.	DATE
LOCATION	447218-C-012	REV	1



11
C-009

DETAIL
FINAL COVER SYSTEM

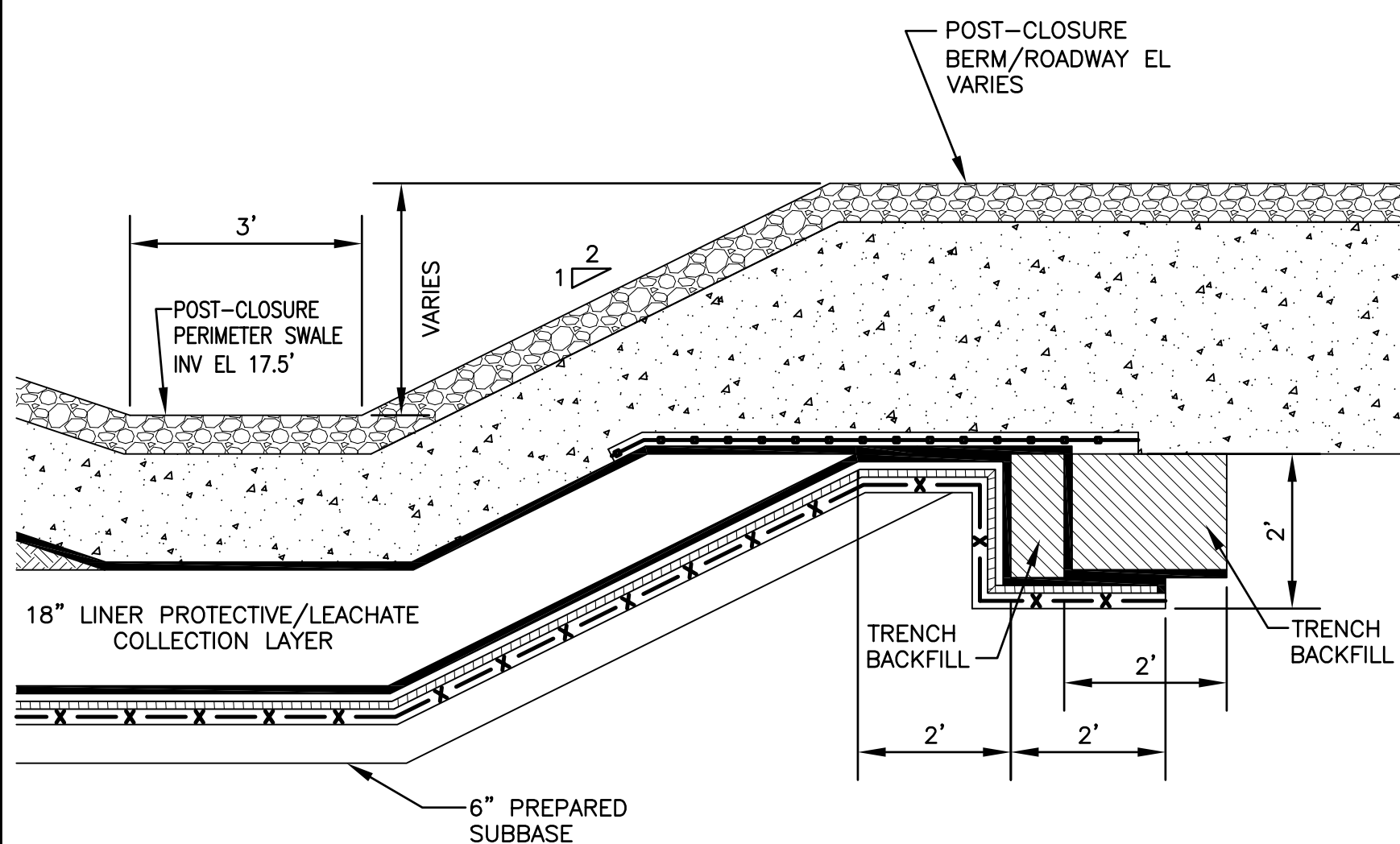
SCALE: 1"= 2'-0" (GEOSYNTHETICS ARE NOT TO SCALE)



12
C-012

TYP. PERIMETER BERM DETAIL
COVER SYSTEM WITHOUT ROADWAY

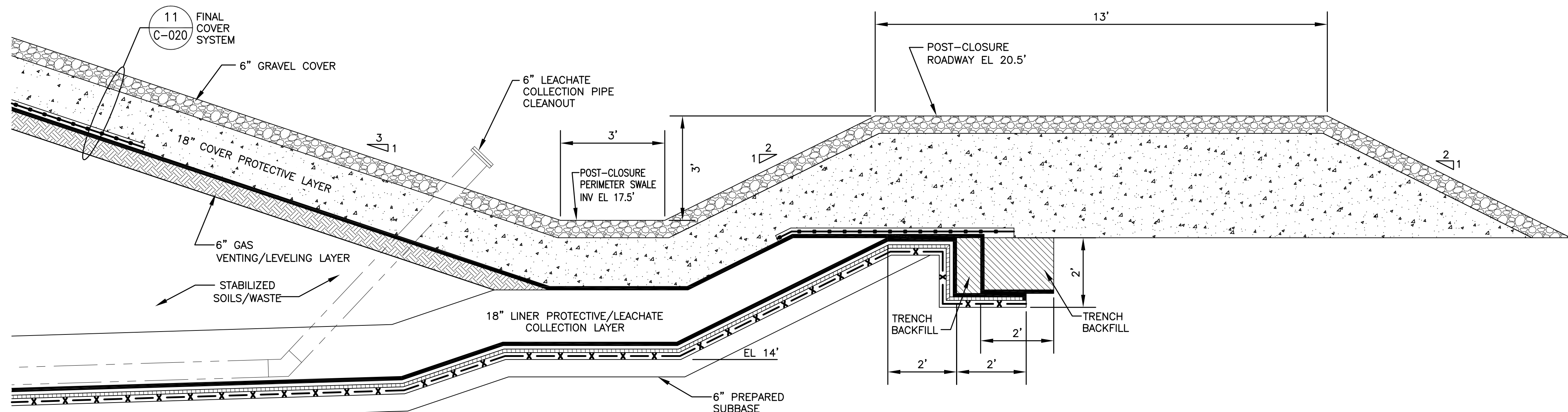
SCALE: 1"= 2'-0" (GEOSYNTHETICS ARE NOT TO SCALE)



2
C-011

TYP. ANCHOR TRENCH DETAIL

SCALE: 1"= 2'-0" (GEOSYNTHETICS ARE NOT TO SCALE)



13
C-012

TYP. ROADWAY BERM DETAIL
COVER SYSTEM WITH ROADWAY

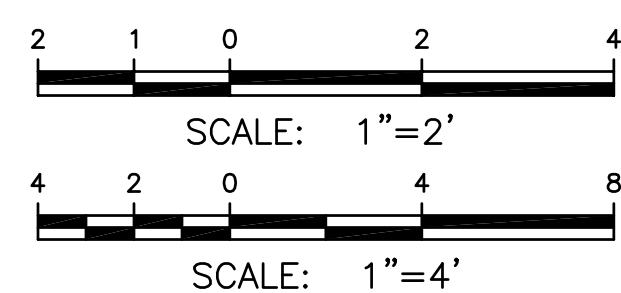
SCALE: 1"= 2'-0" (GEOSYNTHETICS ARE NOT TO SCALE)

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY

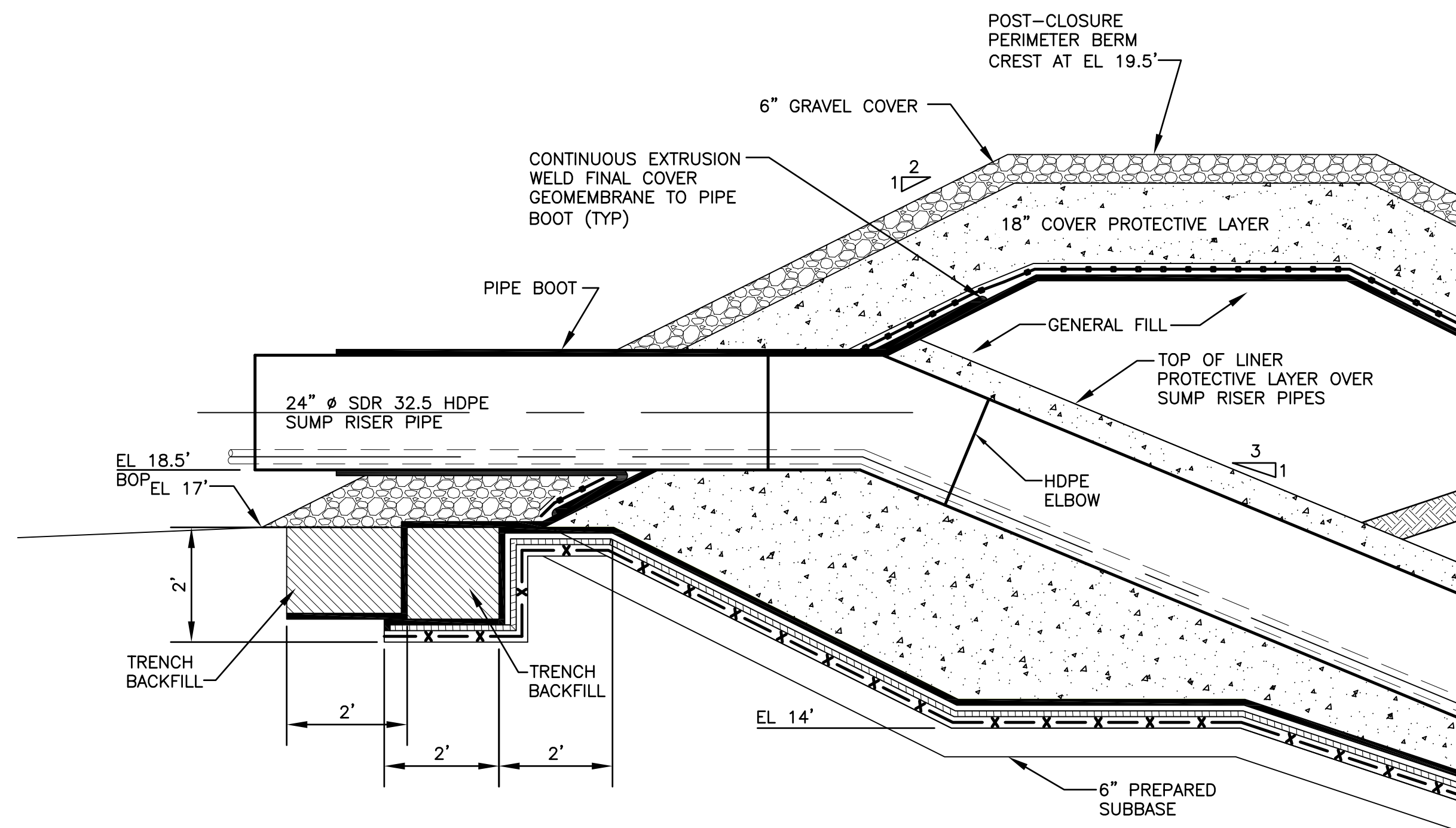
THIS DOCUMENT IS THE PROPERTY OF CHEVRON, PERTH AMBOY FACILITY PREPARED BY PARSONS, AND IS PROVIDED UPON THE CONDITION THAT IT WILL NEITHER BE REPRODUCED, COPIED, ISSUED TO A THIRD PARTY, WILL BE USED SOLELY FOR THE ORIGINAL INTENDED PURPOSE AND SOLELY FOR THE EXECUTION OR REVIEW OF THE ENGINEERING AND CONSTRUCTION OF THE PROJECT



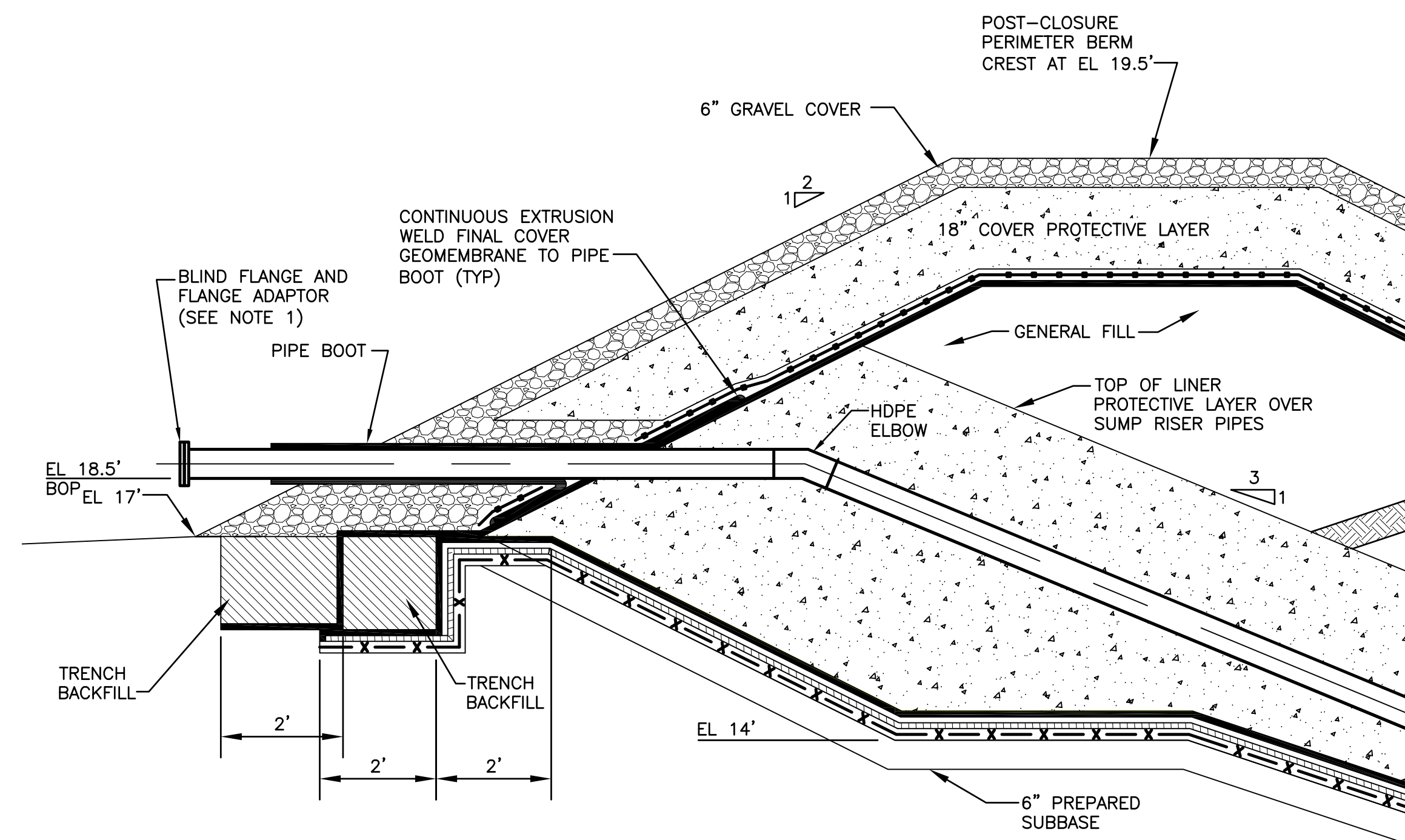
JOB NO. 447218-03101		FINAL COVER SYSTEM DETAILS 1	
CERTIFICATE OF AUTHORIZATION NO. 246A28098300		CAMU FINAL DESIGN	
SCALE: AS SHOWN		PARSONS	
200 COTTONTAIL LANE SOMERSET, NJ 08873		JHG DRAWN LOCATION	9/15/12 DATE 447218-C-020
		AG CHK.	10/27/12 DATE REV 0



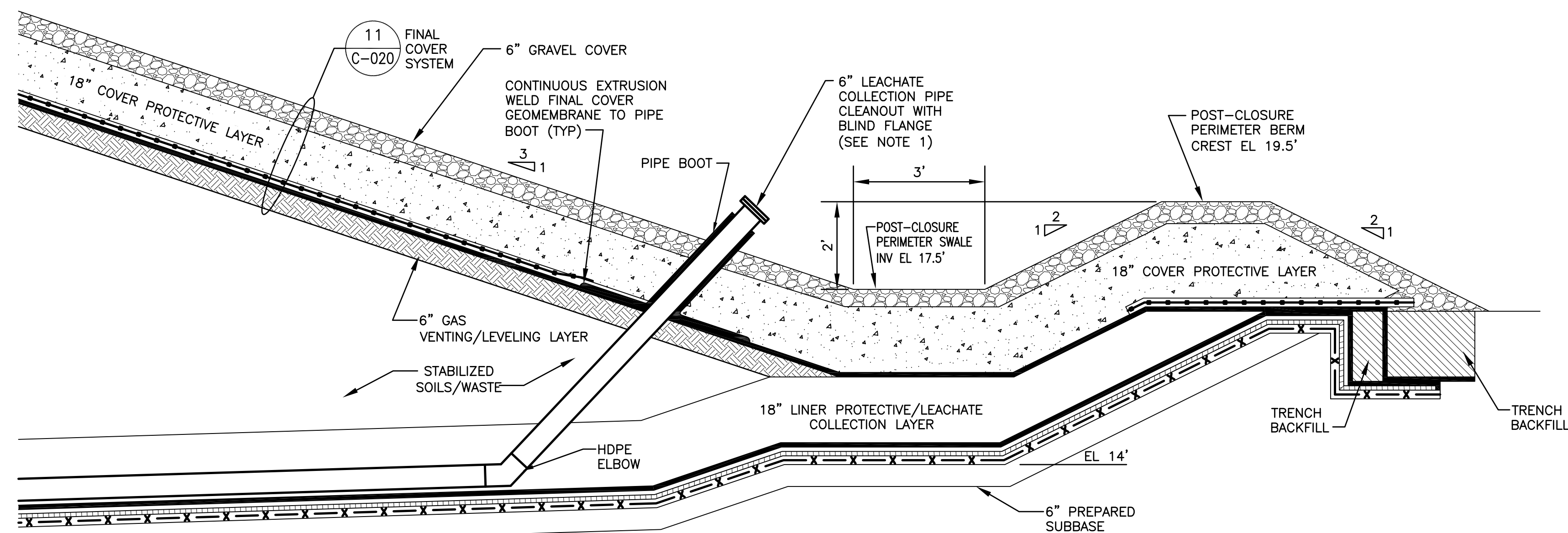
NO.	REVISION	BY	APPR.	APPR.	APPR.	DATE	REFERENCE	DWG. NO.
0	ISSUED FOR CONSTRUCTION	M.S.	L.H.	M.F.	---	05/11/20		



14
C-008
DETAIL
PIPE BOOT FOR PERIMETER SUMP RISER PIPE
SCALE: 1"= 2'-0" (GEOSYNTHETICS ARE NOT TO SCALE)



15
C-008
DETAIL
PIPE BOOT FOR CLEANOUT PIPES
SCALE: 1"= 2'-0" (GEOSYNTHETICS ARE NOT TO SCALE)

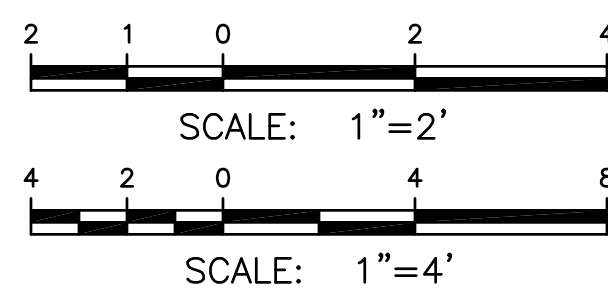


16
C-008
DETAIL
PIPE BOOT FOR CLEANOUT PIPES
SCALE: 1"= 2'-0" (GEOSYNTHETICS ARE NOT TO SCALE)

NOTES:

1. LEACHATE COLLECTION PIPES WERE INSTALLED DURING PREVIOUS PHASES OF THE PROJECT. DETAILS ARE SHOWN HERE FOR INFORMATIONAL PURPOSES. DETERMINE IF EACH ONE PROTRUDES ENOUGH TO NOT BE COVERED BY THE CAP BEING INSTALLED. IF THE TOP OF THE PIPE WILL BE COVERED ADD AN EXTENSION PIECE OF PIPE AND NEW FLANGE TO THE EXISTING FLANGE.
2. GENERAL FILL SHALL BE THE SAME AS SUBBASE FILL SPECIFIED IN SPECIFICATION 02200.

DRAWING IS
HALF-SIZE IF
PLOTTED 11x17



NO.	REVISION	BY	APPR.	APPR.	APPR.	DATE	REFERENCE	DWG. NO.
0	ISSUED FOR CONSTRUCTION	M.S.	L.H.	M.F.	---	05/11/20		

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY
THIS DOCUMENT IS THE PROPERTY OF CHEVRON, PERTH AMBOY FACILITY PREPARED BY PARSONS, AND IS PROVIDED UPON THE CONDITION THAT IT WILL NEITHER BE REPRODUCED, COPIED, ISSUED TO A THIRD PARTY, WILL BE USED SOLELY FOR THE ORIGINAL INTENDED PURPOSE AND SOLELY FOR THE EXECUTION OR REVIEW OF THE ENGINEERING AND CONSTRUCTION OF THE PROJECT



CHEVRON
1200 STATE STREET
PERTH AMBOY, NJ 08861

JOB NO. 447218-03101
CERTIFICATE OF AUTHORIZATION
NO. 240A28098300

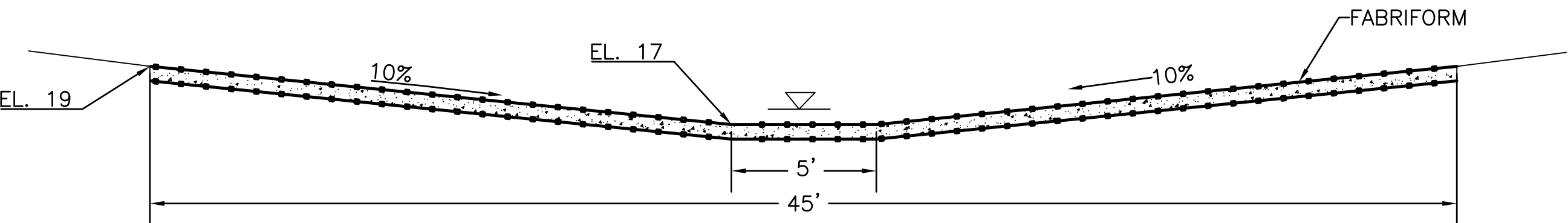
FINAL COVER SYSTEM DETAILS 2

SCALE: AS SHOWN

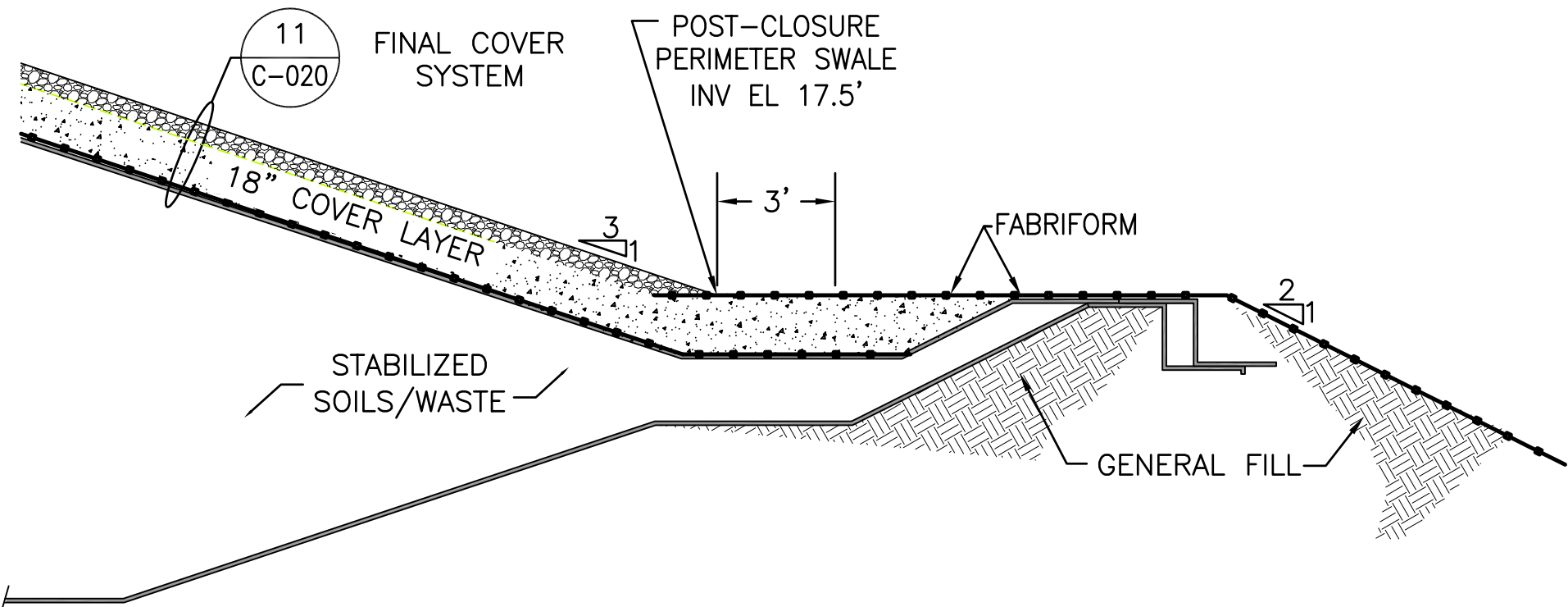
CAMU FINAL DESIGN

PARSONS
200 COTTONTAIL LANE
SOMERSET, NJ 08873

JHG	9/15/12	AG	10/27/12
DRAWN	DATE	CHK.	DATE
LOCATION	447218-C-021	REV	0

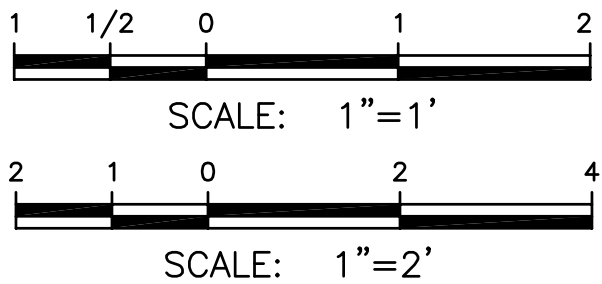


C SPILLWAY SECTION
C-008 SCALE: 1/4"= 1'-0"



I DETAIL SPILLWAY
C-008 SCALE: 1/4"= 1'-0"

- NOTES:
1. WITHIN THE SPILLWAY, LOWER GEOMEMBRANE ALONG PERIMETER BERM TO EL 16.5. INSTALL 6" FABRIFORM (UNIMAT)



DRAWING IS
HALF-SIZE IF
PLOTTED 11x17

NO.	REVISION	BY	APPR.	APPR.	APPR.	CYX	DATE
0	ISSUED FOR CONSTRUCTION	M.S.	L.H.	M.F.	---	-	05/11/20

REFERENCE

DWG. NO.

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY
THIS DOCUMENT IS THE PROPERTY OF CHEVRON, PERTH AMBOY FACILITY PREPARED BY PARSONS, AND IS PROVIDED UPON THE CONDITION THAT IT WILL NEITHER BE REPRODUCED, COPIED, ISSUED TO A THIRD PARTY, WILL BE USED SOLELY FOR THE ORIGINAL INTENDED PURPOSE AND SOLELY FOR THE EXECUTION OR REVIEW OF THE ENGINEERING AND CONSTRUCTION OF THE PROJECT



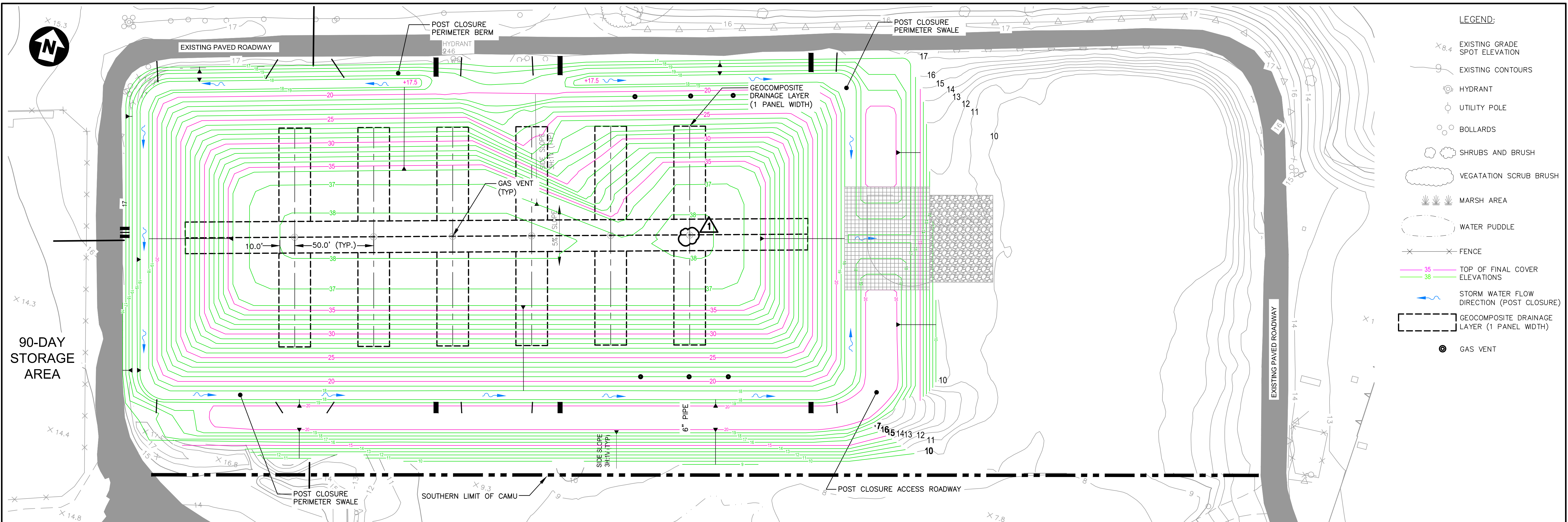
CHEVRON
1200 STATE STREET
PERTH AMBOY, NJ 08861

JOB NO. 447218-03101
CERTIFICATE OF AUTHORIZATION
NO. 24GA28098300

SCALE: AS SHOWN
PARSONS
200 COTTONTAIL LANE
SOMERSET, NJ 08873

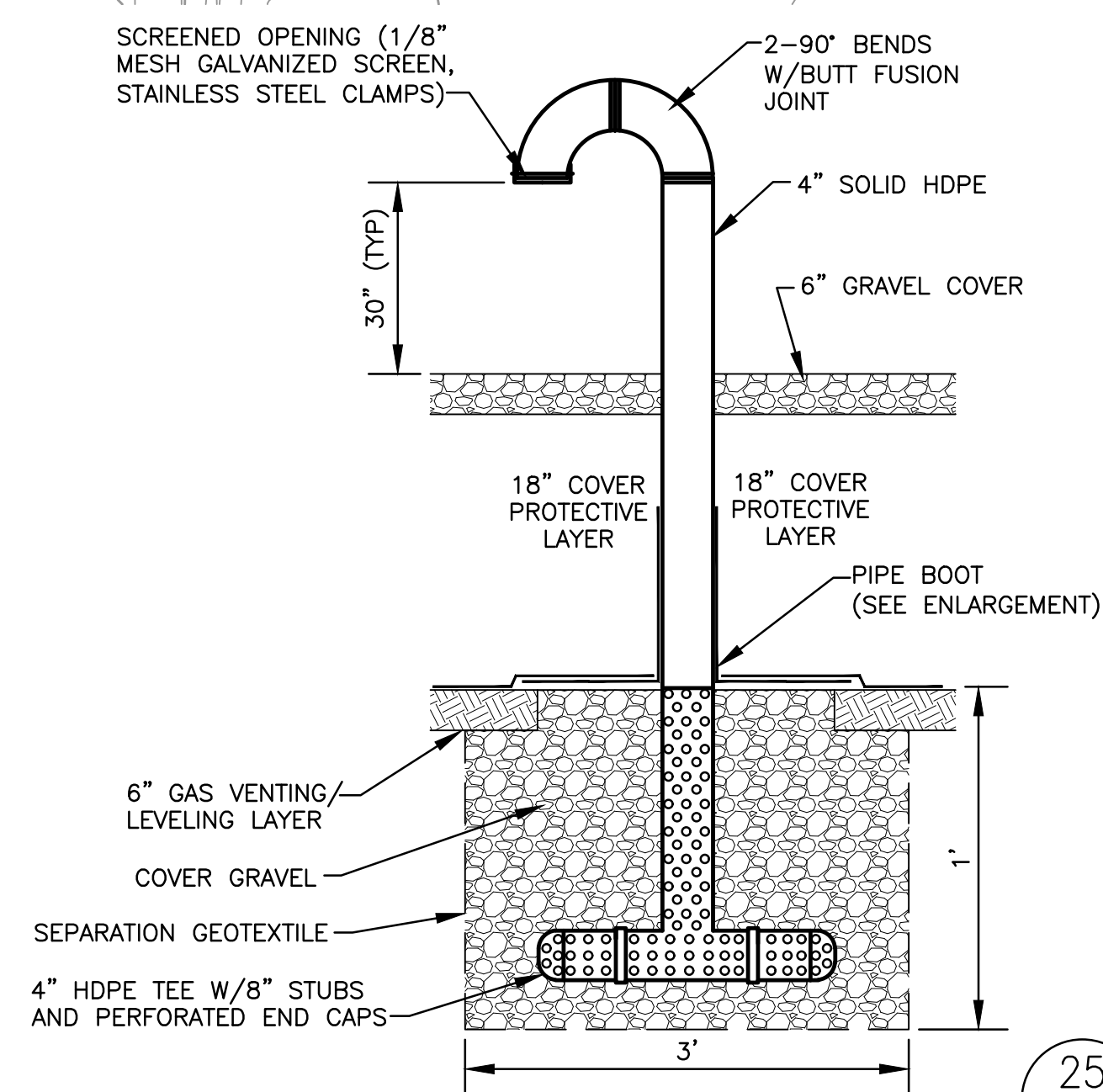
POST-CLOSURE STORM WATER
SYSTEM DETAILS
CAMU FINAL DESIGN

JHG	9/15/12	AG	10/27/12
DRAWN	DATE	CHK.	DATE
LOCATION	447218-C-025	REV	0



GAS VENT SYSTEM LAYOUT PLAN

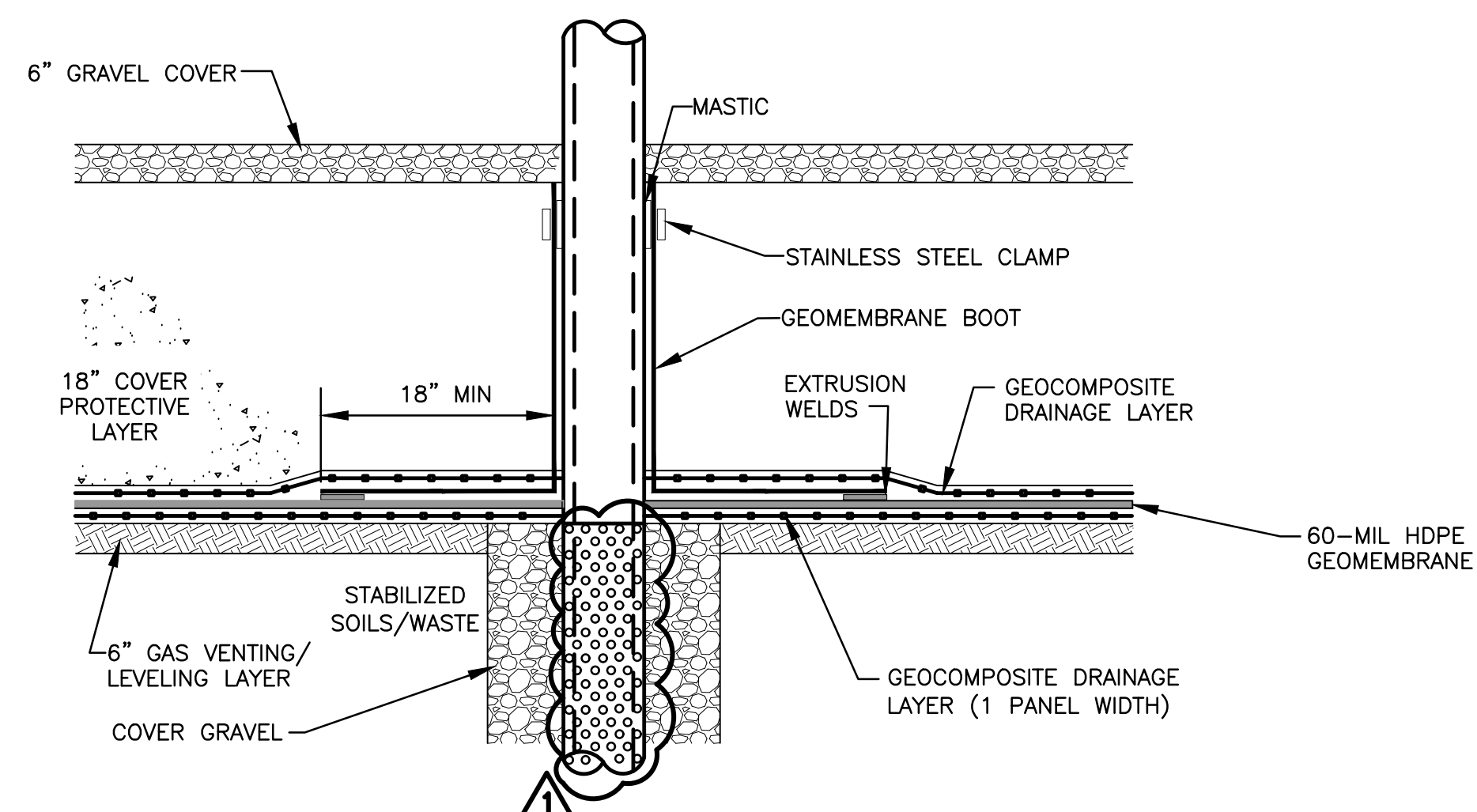
SCALE: 1" = 30'



25
C-008

DETAIL
GAS VENT AND BOOT

SCALE: NOT TO SCALE

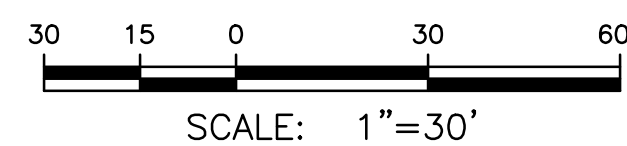


- NOTES:

1. GAS VENTS SHALL BE PLACED WITH 50FT SPACING BETWEEN THEM.
2. THE GAS VENT ON THE EAST SIDE OF THE CAMU MAY BE ADJUSTED BY 10FT IN EITHER DIRECTION TO AVOID INTERFERENCE WITH THE ACCESS ROAD TO THE TOP OF THE CAMU.



DRAWING IS
HALF-SIZE IF
PLOTTED 11x17

[illegible]

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY

"THIS DOCUMENT IS THE PROPERTY OF CHEVRON,
PERTH AMBOY FACILITY PREPARED BY PARSONS, AND IS
PROVIDED UPON THE CONDITION THAT IT WILL NEITHER BE
REPRODUCED, COPIED, ISSUED TO A THIRD PARTY, WILL BE
USED SOLELY FOR THE ORIGINAL INTENDED PURPOSE AND
SOLELY FOR THE EXECUTION OR REVIEW OF THE ENGINEERING
AND CONSTRUCTION OF THE PROJECT"

JOB NO. 447218-03101
CERTIFICATE OF AUTHORIZATION
NO. 24GA28098300

SCALE: AS SHOWN



CHEVRON
1200 STATE STREET
PERTH AMBOY, NJ 08861

PASSIVE GAS VENTING SYSTEM

CAMU FINAL DESIGN

PARSONS
200 COTTONTAIL LANE
SOMERSET, NJ 08873

JHG	9/15/12	AG	10/27/12
DRAWN	DATE	CHK.	DATE
LOCATION	447218-C-026		
	REV 1		

**CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)
CAP CONSTRUCTION
CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN**

**CHEVRON PERTH AMBOY FACILITY
PERTH AMBOY, NEW JERSEY**



**Chevron Environmental Management Company
Perth Amboy, New Jersey**

Prepared By:

PARSONS
200 Cottontail Lane
Somerset, New Jersey 08873

May 2020

Project No. 450335-32310

TABLE OF CONTENTS

1. INTRODUCTION.....	1
1.1 Overview.....	1
1.2 Project Description.....	1
1.3 CQA Plan Scope.....	1
1.4 CQA Plan Organization	2
2. CQA PLAN DEFINITIONS.....	3
2.1 CQA and CQC	3
2.2 Plans and Specifications	3
2.3 Geosynthetics.....	3
2.4 Construction Activities.....	3
2.5 CQA Lines of Communications.....	4
3. PROJECT ORGANIZATION AND PERSONNEL.....	5
3.1 Overview.....	5
3.2 Construction Manager.....	5
3.3 Engineer	5
3.4 Contractor.....	5
3.5 CQA Consultant.....	9
3.5.1 Definition.....	9
3.5.2 Qualifications.....	9
3.5.3 Responsibilities.....	9
3.5.3.1 CQA Managing Engineer.....	10
3.5.3.2 CQA Site Manager.....	10
3.5.3.3 CQA Field Monitors.....	11

3.6	Geotechnical CQA Laboratory	12
3.6.1	Definition.....	12
3.6.2	Qualifications.....	12
3.6.3	Responsibilities.....	12
3.7	Geosynthetics CQA Laboratory	13
3.7.1	Definition.....	13
3.7.2	Qualifications.....	13
3.7.3	Responsibilities.....	13
3.8	Geosynthetics Manufacturers	14
3.9	Geosynthetics Installers	14
3.10	Surveyor	14
4.	DOCUMENTATION	16
4.1	Overview.....	16
4.2	Daily Record Keeping	16
4.2.1	Daily Summary Reports	16
4.2.2	CQA Monitoring Data Sheets.....	17
4.2.3	Nonconformance Identification and Reporting	17
4.3	Photographic Documentation	18
4.4	Design and/or Specifications Changes.....	19
4.5	Nonconformances	19
4.6	CQA Certification Report	19
4.7	Storage of Records.....	20
5.	SOILS AND GRAVELS	21
5.1	Introduction	21
5.2	Soil and Gravel Components.....	21
5.3	Related Technical Specifications	21
5.4	Conformance Testing	21

5.4.1	Test Methods	22
5.4.2	Test Frequency.....	22
5.5	Construction Monitoring.....	22
5.6	Performance Testing.....	23
5.6.1	Test Methods	23
5.6.2	Test Frequency.....	23
5.7	Deficiencies	24
5.8	As-Built Surveys	24
5.9	Documentation	24
6.	GEOMEMBRANE	27
6.1	Introduction	27
6.2	Manufacturing Plant Visit	27
6.3	Transportation, Handling and Storage.....	27
6.4	Conformance Testing	27
6.4.1	Sampling Procedures	27
6.4.2	Testing Procedures.....	28
6.4.3	Test Results	28
6.4.4	Conformance Test Failure	28
6.5	Anchor Trench.....	28
6.6	Geomembrane Placement	29
6.6.1	Field Panel Identification	29
6.6.2	Field Panel Placement	29
6.7	Field Panel Seaming	30
6.7.1	Panel Layout	30
6.7.2	Seaming Equipment and Products.....	31
6.7.2.1	<i>Fusion Process</i>	31
6.7.2.2	<i>Extrusion Process</i>	31
6.7.3	Seam Preparation	32
6.7.4	Weather Conditions for Seaming.....	32
6.7.5	Overlapping and Temporary Bonding.....	33
6.7.6	Trial Seams	33

6.7.7	General Seaming Procedures.....	33
6.7.8	Non-Destructive Seam Continuity Testing	34
6.7.9	Destructive Testing	34
6.7.9.1	Frequency and Location.....	34
6.7.9.2	Sampling Procedures	35
6.7.9.3	Size of Samples.....	35
6.7.9.4	Field Testing.....	35
6.7.9.5	Geosynthetics CQA Laboratory Testing	36
6.7.9.6	Procedures for Destructive Test Failure	36
6.8	Defects and Repairs	37
6.8.1	Identification	37
6.8.2	Repair Procedures	37
6.8.3	Verification of Repairs	37
6.9	Liner System Acceptance.....	38
6.10	Materials in Contact with the Geomembrane	38
6.10.1	Soils.....	38
6.10.2	Appurtenances.....	38
7.	GEOTEXTILES	42
7.1	Introduction	42
7.2	Transportation, Handling, and Storage	42
7.3	Placement	43
7.4	Seams and Overlaps	43
7.5	Repairs.....	43
7.6	Placement of Materials	44
8.	GEOSYNTHETIC DRAINAGE LAYER.....	45
8.1	Introduction	45
8.2	Transportation, Handling, and Storage.....	45
8.3	Record.....	45
8.4	Surface Preparation.....	45

8.5	Placement.....	45
8.6	Overlaps	46
8.7	Repairs	46
9.	PIPES AND FITTINGS	47
9.1	Introduction	47
9.2	Butt-Fusion Welding Process.....	47
9.3	Transportation, Handling, and Storage	47
9.4	Installation	47
9.5	Materials	47

LIST OF TABLES

Table 5-1	Minimum Conformance Testing Frequencies for Soil and Gravel Components.....	25
Table 5-2	Minimum Performance Testing Frequencies for Soil and Gravel Components.....	26
Table 6-1	Geomembrane Conformance Testing Requirements.....	40
Table 6-2	Geomembrane Seam Testing Requirements.....	41
Table 7-1	GCL Conformance Testing Requirements.....	45
Table 9-1	High Strength Reinforcement Conformance Testing Requirements.....	53

LIST OF FIGURES

Figure 3-1	CAMU Construction Organization Chart.....	7
Figure 3-2	CQA Organization Chart	8

LIST OF APPENDIX

Appendix A	CQA Forms and Logs
------------	--------------------

1. INTRODUCTION

1.1 Overview

This Construction Quality Assurance (CQA) Plan describes the quality assurance activities that will be undertaken during construction of the Corrective Action Management Unit (CAMU) at former Chevron facility in Perth Amboy, New Jersey (Facility). The purpose of this document is to define the scope, formal organization, and procedures necessary to achieve a high level of quality and to monitor that the construction of the CAMU is in compliance with the Construction Drawings and the Technical Specifications. This plan addresses the CQA activities that will be performed during construction.

1.2 Project Description

Cell 1 of the CAMU was constructed in 2014 and Cell 2 of the CAMU was constructed in 2017. The construction requirements for the CAMU Cap are included in the Construction Drawings and Technical Specifications. The construction of CAMU Cap includes the following major activities:

- Implementing the sediment and erosion control measures;
- Performing general earthwork in to prepare the Cells to be covered;
- Constructing a composite cap system;
- Constructing roadway on North and East side of the CAMU;
- Constructing a spillway for stormwater drainage; and
- Installing gas collection system.

1.3 CQA Plan Scope

The CQA Plan establishes the quality assurance monitoring and testing activities that will be implemented by the CQA Consultant during the construction of CAMU Cap (i.e., during implementation of the major activities described above). The CQA Plan was developed keeping in consideration the CAMU regulations and typical guidelines for construction of similar facilities. The scope of the CQA Plan includes:

- Defining the responsibilities of the parties involved in the construction of the CAMU;
- Providing guidance for proper implementation of the various construction activities;
- Establishing testing protocols for evaluation of the various construction activities;
- Establishing procedures for construction documentation; and

- Providing the means for checking that the overall construction conforms to the requirements in the Construction Drawings and the Technical Specifications.

The CQA Plan is intended to establish procedures for the CQA Consultant and to inform the Contractor of CQA activities during the construction of the CAMU. The CQA Plan is considered a supplement to the Technical Specifications and a part of the Construction Documents. In case of any conflict between the CQA procedures described in this plan and the requirements of the Technical Specifications, the Technical Specifications will govern.

1.4 CQA Plan Organization

The remainder of this CQA Plan is organized as follows:

- definitions of key terms are presented in Section 2;
- project organization and descriptions, responsibilities, and qualifications of key parties involved with the construction of the CAMU are presented in Section 3;
- requirements for CQA documentation are described in Section 4;
- CQA activities for the soil and gravel components of the CAMU are presented in Section 5;
- CQA activities for geosynthetics are presented in Sections 6 through 8; and
- CQA activities for piping and fittings are included in Section 9.

2. CQA PLAN DEFINITIONS

2.1 CQA and CQC

In the context of this document, CQA and CQC are defined as follows:

- Construction Quality Assurance (CQA) - The planned and systematic means and actions designed to check with adequate confidence that the materials and/or services meet contractual and regulatory requirements and will perform satisfactorily in service.
- Construction Quality Control (CQC) - Those actions which provide a means to measure and regulate the characteristics of an item or service in relation to contractual and regulatory requirements.

In the context of this document:

- CQA refers to means and actions employed by the CQA Consultant, Engineer, or Construction Manager to check conformity of the various components of the construction with the requirements of the Construction Drawings and the Technical Specifications.
- CQC refers to the actions taken by the Contractor, Manufacturers, or Installers to verify that the materials and the workmanship of the various components of the construction meet the requirements of the Construction Drawings and the Technical Specifications.

2.2 Plans and Specifications

In this CQA Plan, reference to Construction Drawings and the Technical Specifications is understood to mean the plans and specifications issued specifically for construction of CAMU Cap. In all cases, it is expected that this CQA Plan will conform to the Construction Drawings and the Technical Specifications. In case of conflict, the approved Construction Drawings and the Technical Specifications will govern.

2.3 Geosynthetics

Geosynthetics is the generic term for all synthetic materials used in geotechnical engineering applications. Three geosynthetic products that will be used in the construction of CAMU Cap include geotextile, geocomposite, and geomembrane.

2.4 Construction Activities

In the context of this CQA Plan, the CAMU construction is understood to include:

- site work including grading and general earthwork;
- geosynthetic components of the composite liner system;

- gas collection system; and
- other construction activities as assigned by the Construction Manager.

2.5 CQA Lines of Communications

Successful execution of this CQA Plan is dependent on open and continuous communication between all parties having a role in the project. The lines of communication between the Owner/Construction Manager, Design Engineer, Contractor, and the CQA Consultant are defined in the organization charts included in Section 3 of this CQA Plan.

3. PROJECT ORGANIZATION AND PERSONNEL

3.1 Overview

The CAMU construction organization chart is shown in Figure 3-1. It is understood that the Project Manager will act on behalf of the Owner (Chevron) in all matters relating to the construction of the CAMU. Day-to-day construction activities of the CAMU will be managed through the direct interaction of several parties reporting to the Project Manager level including but not limited to the Construction Manager, Engineer, Contractor, and CQA Consultant.

The organization chart for the CAMU CQA Consultant is presented in Figure 3-2. The description, qualifications, and responsibilities of the parties responsible for construction and CQA of the CAMU project are described below.

3.2 Construction Manager

The Construction Manager will be an individual employed by the Owner and who is responsible for overall management of the construction project at the site. In this CQA plan, the term "Construction Manager" will refer specifically to an authorized representative of the Owner. The Construction Manager will have relevant construction experience. The Construction Manager will be responsible for coordination and oversight of the construction activities.

3.3 Engineer

The Engineer is the individual representing the firm responsible for the CAMU design. The Engineer will hold a minimum of a baccalaureate degree in engineering and have 10 years experience in construction management, engineering, or related fields. The Engineer will have expertise which demonstrates significant familiarity with geosynthetics and soils, as appropriate, including design and construction experience related to CAMU final cover system.

The Engineer will be responsible for approving the design and specification changes and making design clarifications that may be required during construction of the CAMU. The Engineer will review and approve the Contractor's shop drawings and submittals. The Engineer will not be present on-site but will visit the project during construction and attend the project coordination meetings as required to monitor conformance with plans and specifications. The Engineer will be capable of discussing and interpreting the elements of the CAMU design. The Engineer will have the authority to recommend changes or modifications to the Construction Drawings and the Technical Specifications for approval by the Construction Manager.

3.4 Contractor

The Contractor is the firm or corporation having a legally binding agreement to construct the CAMU hired directly by the Owner. The Contractor is represented on-site by a qualified individual who is authorized to act on behalf of the Contractor in all matters pertaining to the construction of the CAMU. The Contractor will be qualified to perform all aspects of work required to successfully construct the CAMU. The Contractor will be registered in accordance

with applicable local, state, and federal requirements and will demonstrate significant prior related experience. The Contractor's field representative will be a qualified individual who can perform all tasks associated with CAMU construction. The Contractor's field representative will demonstrate experience similar to that of the Construction Manager. The Contractor's field representative will have the authority to direct and instruct the Contractor's crews and their subcontractors.

The Contractor is responsible for all construction materials, activities, and CQC monitoring and testing. The Contractor is also responsible for scheduling and coordination of the required work with its subcontractors to complete the project in accordance with the schedule agreed with the Construction Manager. The Contractor will provide an experienced supervisory representative at all times during any construction activity on-site. The Contractor is responsible for furnishing as-built record drawings and a copy of all documentation required during the construction of the CAMU. The Contractor is also responsible for updating all Construction Drawings for any deviations from the original plans and the Technical Specifications on a regular basis.

The Contractor's field representative is responsible for coordinating and supervising the work of all subcontractors on site. At a minimum, the Contractor's field representative will be responsible for the following:

- informing the Construction Manager of any discrepancies between the plans and specifications and the field conditions;
- submitting all documentation required by the Construction Drawings and the Technical Specifications in a timely manner;
- attending all project coordination meetings held on site;
- scheduling all phases of the construction;
- maintaining a daily log of the construction activities on site;
- implementing and verifying all CQC procedures required of the Contractor and/or subcontractors; and
- submitting proposed alternative materials or construction methods to the Construction Manager for approval prior to acquisition and use.

Figure 3-1

CAMU Construction Organization Chart

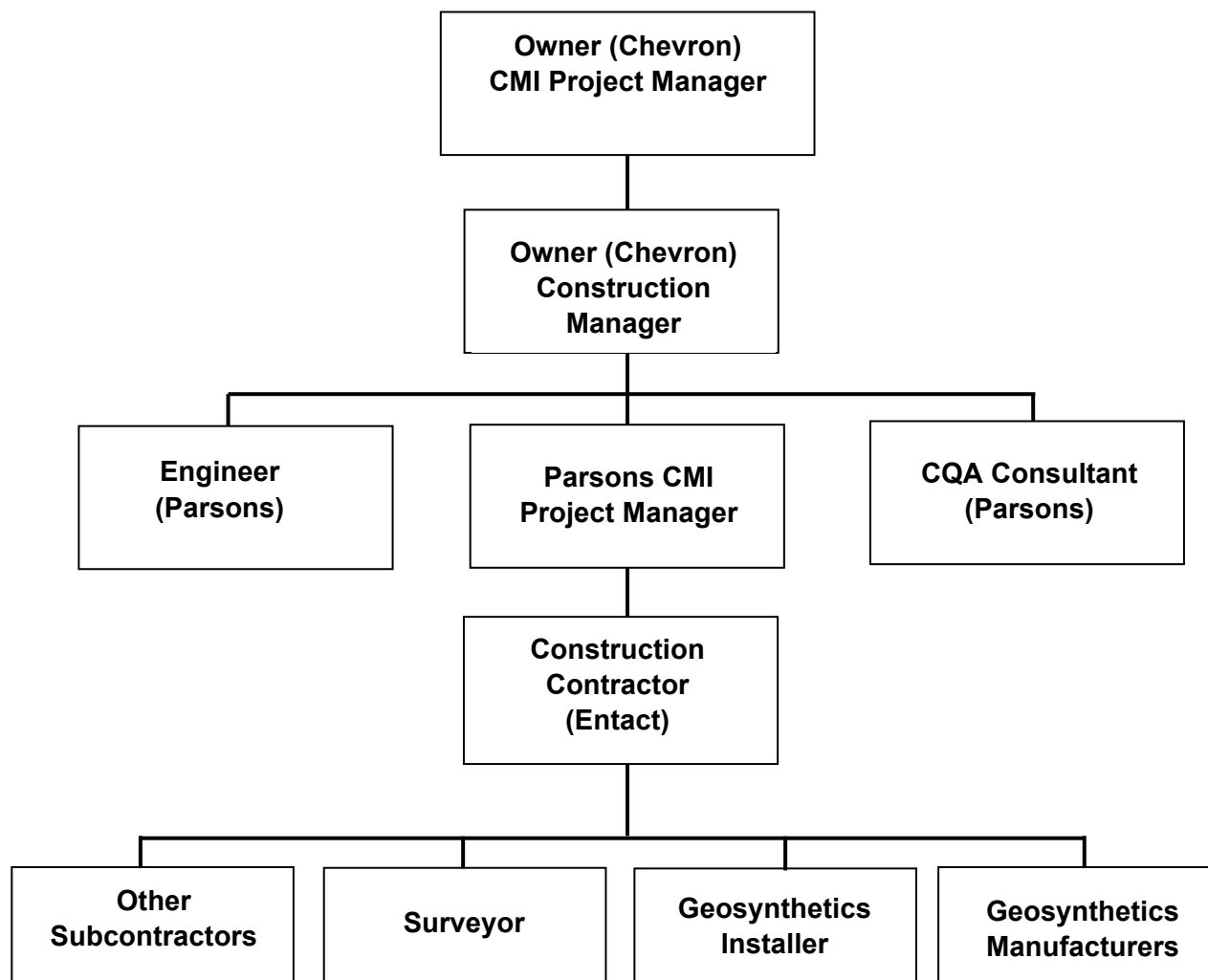
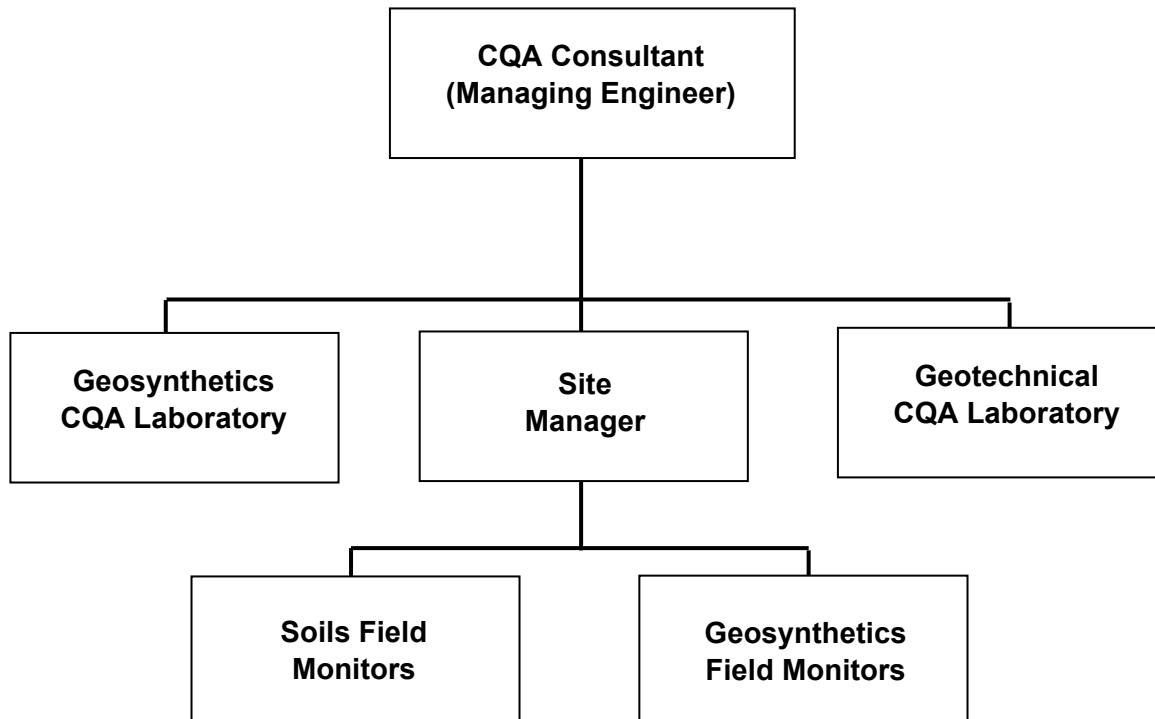


Figure 3-2
CQA Organization Chart



3.5 CQA Consultant

3.5.1 Definition

The CQA Consultant is the party, independent from the Owner and the Contractor, responsible for observing, testing, and documenting activities related to the CQA of the soil, gravel, geosynthetic components, and other activities related to the construction of the CAMU as described in this CQA Plan.

3.5.2 Qualifications

The CQA Consultant will be a well-established firm specializing in geotechnical engineering, liner system design, construction management, and CQA. The CQA Consultant will possess the equipment, personnel, and licenses necessary to conduct the monitoring and testing activities required by this CQA Plan, the CAMU Construction Drawings and the Technical Specifications. The CQA Consultant will also be experienced in the installation and CQA of soil, gravel, and geosynthetic materials similar to those that will be used in the construction of the CAMU. The CQA Consultant will be experienced in the preparation of CQA documentation including CQA plans, field documentation, field and laboratory test records, construction plans, and CQA certification reports. The CQA Consultant will provide qualified staff for the project.

The CQA Consultant organization will be led by the CQA Managing Engineer, who will hold a baccalaureate degree in engineering. The CQA Site Manager will be the representative of the CQA Consultant on site and will have experience in similar construction and be specifically familiar with the construction of soil and geosynthetic components of the CAMU.

3.5.3 Responsibilities

CQA Consultant will be responsible for: (i) monitoring and documenting the activities of the Contractor related to earthwork, installation of the cover liner system, and various appurtenances related to the construction of the CAMU; (ii) monitoring compliance of the construction materials delivered to the site with the submittals and/or shop drawings previously reviewed and approved by the Engineer; (iii) monitoring that the Contractor's construction methods and workmanship are performed in accordance with the Construction Drawings and the Technical Specifications; (iv) obtaining and testing samples of the various construction materials in accordance with the testing frequencies identified in this plan; and (v) obtaining, labeling, and shipping samples for off-site laboratory testing.

CQA Consultant will also be responsible for the quality control of its on-site testing equipment and for documenting the calibration of the testing equipment. CQA Consultant will submit test results to the Engineer within a time frame that will not impede or delay construction of activities.

The duties of the CQA Personnel are discussed in the following subsections.

3.5.3.1 CQA Managing Engineer

The CQA Managing Engineer:

- reviews the Construction Drawings and the Technical Specifications;
- reviews soil, gravel and geosynthetics-related documents (such reviews are for familiarization and for evaluation of constructability only);
- attends project meetings related to construction quality activities;
- administers the CQA program (i.e., assigns and manages the on-site CQA personnel, reviews the field reports, and provides engineering review of the CQA-related activities);
- provides quality control of CQA documentation;
- reviews changes to the construction design, and verify that major changes are submitted to Engineer for approval prior to incorporation into the Construction Drawing and the Technical Specifications; and
- with the CQA Site Manager, prepares the final certification report.

3.5.3.2 CQA Site Manager

The CQA Site Manager:

- acts as the on-site representative of the CQA Consultant;
- familiarizes the CQA Field Monitors with the site, project documents, and the CQA requirements;
- manages the daily activities of the CQA Field Monitors;
- attends regularly scheduled CQA-related meetings on-site;
- reviews the ongoing preparation of the construction record drawings;
- reviews test results provided by the Contractor;
- checks the calibration and condition of on-site testing equipment;
- reviews the CQA Field Monitors' daily reports and logs;
- documents in a daily report the relevant observations by the CQA Field Monitors;
- prepares a daily report for the project;

- oversees the collection and shipping of laboratory test samples;
- reviews results of laboratory testing and makes appropriate recommendations;
- reports any unresolved deviations from the CQA Plan, Construction Drawings and/or the Technical Specifications to the Construction Manager;
- assists with the preparation of the final certification report;
- reviews appropriate certifications and documentation from the Contractor and the Geosynthetics Manufacturer and Installer, and makes appropriate recommendations;
- reviews the Geosynthetics Manufacturer's QC documentation;
- reviews the geosynthetics Installer's personnel qualifications for conformance with the requirements in the Technical Specifications; and
- performs duties of CQA Field Monitor, if needed.

3.5.3.3 CQA Field Monitors

The duties of the CQA Field Monitors are monitoring and documenting construction of the soil, gravel, and geosynthetics components of the CAMU as assigned by the CQA Site Manager. The duties of the CQA Field Monitors will include:

- monitoring material stockpiles for any deterioration of materials;
- monitoring surface-water drainage in the areas of soil and geosynthetic material stockpiles;
- preparing daily field reports;
- recording CQA and CQC activities on field logs;
- reporting problems to the CQA Site Manager;
- monitoring soil and gravel placement and/or compaction operations;
- monitoring the unloading and on-site handling and storage of the geosynthetics;
- monitoring geosynthetic material deployment and installation operations;
- monitoring geosynthetic repair operations;
- assisting with collection of samples from the constructed components in accordance with the CQA Plan; and

- collecting and shipping samples to offsite CQA laboratories for testing.

In addition to these specific duties, the CQA Field Monitors will document any on-site activities that could result in damage to the soil, gravel or geosynthetic components of the CAMU. This is particularly important during the placement and compaction of the initial lift of soil on top of the geomembrane. Any such observations by the CQA Field Monitors will be reported immediately to the CQA Site Manager.

3.6 Geotechnical CQA Laboratory

3.6.1 Definition

The Geotechnical CQA Laboratory is the party, independent from the Owner and Contractor, responsible for conducting geotechnical laboratory tests in accordance with standards referenced in the Construction Drawings, Technical Specifications and/or this CQA Plan. The testing results generated by the Geotechnical CQA Laboratory will be used by the CQA Consultant to check compliance of the soil and gravel construction materials with the plans, specifications and/or the submittals previously approved by the Engineer.

3.6.2 Qualifications

The Geotechnical CQA Laboratory will be experienced in testing of soil and gravel similar to those proposed for use in the construction of the CAMU in accordance with ASTM or other applicable soil test standards. The Geotechnical CQA Laboratory will be capable of providing test results within a maximum of 7 working days of receipt of the samples and will maintain that capability throughout the duration of the earthwork construction.

Prior to construction, the Geotechnical CQA Laboratory will submit their qualifications and QA/QC procedures upon request to the Engineer for review. The qualifications presented by the Soils CQA Laboratory will, as a minimum, include:

- corporate background and statement of qualifications;
- list of testing capabilities including reference to ASTM test methods;
- a laboratory QA/QC plan;
- information on staff size and experience; and
- information regarding test result turnaround time.

3.6.3 Responsibilities

The Geotechnical CQA Laboratory will be responsible for testing various soil and gravel components of the CAMU. These tests will include, but not be limited to, material qualification (conformance) tests and material construction quality assurance (performance) tests as

described in this CQA Plan. The CQA Consultant will be responsible for coordinating the required testing.

3.7 Geosynthetics CQA Laboratory

3.7.1 Definition

The Geosynthetics CQA Laboratory is the party, independent from the Owner, Contractor, and geosynthetics Manufacturer and Installer, responsible for conducting tests on samples of geosynthetic materials used in construction of the CAMU in accordance with standards referenced in the Construction Drawings, Technical Specifications and/or this CQA Plan. The testing results generated by the Geosynthetics CQA Laboratory will be used by the CQA Consultant to check compliance of the geosynthetic materials with plans, specifications and/or the submittals previously approved by the Engineer.

3.7.2 Qualifications

The Geosynthetics CQA Laboratory will hold current accreditation by Geosynthetic Research Institute (GRI) or be approved by the Engineer and have experience in testing geosynthetics similar to those proposed for use during construction of the CAMU. The Geosynthetics CQA Laboratory will be familiar with ASTM and other applicable geosynthetics test standards. The Geosynthetics CQA Laboratory will be capable of providing destructive test results for geomembrane field seams within 24 hours of receipt of the samples and will maintain that capability throughout the duration of geosynthetics material installation.

Prior to construction, the Geosynthetics CQA Laboratory will submit their qualifications upon request to the Engineer for review and approval. The qualifications presented by the Geosynthetics CQA Laboratory will, as a minimum, include:

- corporate background and statement of qualifications;
- listing of testing capabilities including reference to ASTM or other applicable test methods;
- a laboratory QA/QC plan;
- information on staff size and experience; and
- information regarding test result turnaround time.

3.7.3 Responsibilities

The Geosynthetics CQA Laboratory will be responsible for testing various geosynthetic components of the CAMU. These tests will include, but not be limited to, geosynthetic materials testing and destructive testing of the geomembrane field seams as described in this CQA Plan. The CQA Consultant will be responsible for coordinating the required testing.

3.8 Geosynthetics Manufacturers

The Geosynthetics Manufacturers are the firms or corporations responsible for production of the geosynthetic materials that will be used in construction of the CAMU. The Geosynthetic Manufacturers will meet the qualifications outlined in the Technical Specifications. The Geosynthetic Manufacturers will be able to provide sufficient production capacity and qualified personnel to meet the needs of the project schedule.

Each Geosynthetics Manufacturer is responsible for the production and quality control of its respective geosynthetic product. In addition, each Geosynthetic Manufacturer is responsible for the condition of the geosynthetics until the material is accepted by the Contractor. Each Geosynthetics Manufacturer will produce a consistent, high quality product that will meet the requirements of the Technical Specifications. Each geosynthetics Manufacturer will submit quality control documentation for its respective products in accordance with the Technical Specifications.

3.9 Geosynthetics Installers

The Geosynthetic Installers will be experienced and qualified to install the geosynthetic materials of the type specified for this project. The Geosynthetic Installers will meet the qualifications outlined in the Technical Specifications. The Geosynthetic Installers will designate one representative as its supervisor, who will be responsible for acting as the geosynthetic Installer's spokesperson on site. The Geosynthetic Installers will provide the Construction Manager with a list of proposed seaming personnel and their qualifications. This document will be reviewed by the CQA Consultant. Final approval of the Geosynthetic Installer's geomembrane seaming personnel will be the responsibility of the Construction Manager. Any proposed seaming personnel deemed insufficiently experienced will not be accepted. The most experienced seamer, the "master seamer", will provide direct supervision, as required, over less experienced seamers. No field seaming will take place without the master seamer being present.

The Geosynthetic Installer's supervisor will be responsible for: (i) installation of the geosynthetic used in construction of the CAMU and for providing supervision and guidance to the installation crew; (ii) obtaining samples, as required by the CQA Plan and the specifications; (iii) field testing; (iv) documenting quality control testing activities; and (v) coordinating the geosynthetic installation activities with the Construction Manager. The Geosynthetic Installer's supervisor will also be responsible for documenting the geosynthetic installation activities, including, but not limited to, on-site personnel, material inventories, production figures, test results, installation deficiencies, and resolution of construction problems.

3.10 Surveyor

The Surveyor is responsible for surveying the limits, grades and elevations required for control of the work on an ongoing basis during all phases of the CAMU construction. Close interaction between the Surveyor, Contractor, and the CQA Consultant is essential to ensure that construction of the CAMU is completed in accordance with the Construction Drawings and the

Technical Specifications. All surveying personnel will be experienced in the provision of surveying services including detailed accurate documentation as required in the Technical Specifications. The Surveyor is responsible for all surveying activities and products in accordance with the Technical Specifications. The project Surveyor responsible for the final construction survey record drawings will be a licensed Land Surveyor meeting the requirements in the Technical Specifications.

4. DOCUMENTATION

4.1 Overview

An effective CQA Plan depends largely on recognition of the construction activities that should be monitored and the assignment of responsibilities for monitoring each activity. This is most effectively accomplished and verified by the documentation of quality assurance and quality control activities. The CQA Consultant will be responsible for monitoring that the Contractor's quality control requirements have been addressed and satisfied.

The CQA Site Manager will provide the Construction Manager daily field reports, data sheets, and logs, upon request, which document that monitoring activities have been accomplished. Examples of some of the forms and logs that will be used to document the CQA activities are included in Appendix A. The CQA Site Manager will also maintain at the job site a complete file of Construction Drawings, Technical Specifications, this CQA Plan, the Contractor's Quality Control Plan(s), checklists, test procedures, daily logs, and other pertinent construction and CQA documents.

4.2 Daily Record Keeping

The CQA Consultant's daily reporting procedures will include: (i) summary of daily activities; (ii) monitoring logs; (iii) test data sheets; and (iv) problems identified and corrective measures taken, as applicable.

4.2.1 Daily Summary Reports

The CQA Consultant's daily summary reports will include the following information, as applicable:

- an identifying sheet number for cross referencing and document control;
- date, project name, location, and other pertinent project identification;
- data on weather conditions;
- summary on meetings held and the results;
- process description(s) and location(s) of construction activities underway during the time frame of report;
- descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- description of locations where tests and samples were taken;
- a narrative summary of field test results;

- offsite materials received, including quality control documentation;
- decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard testing results;
- identifying sheet numbers of data sheets and/or problem reporting and corrective measures reports used to substantiate the decisions described above; and
- signature of the respective CQA Site Manager and/or the CQA Field Monitor.

4.2.2 CQA Monitoring Data Sheets

Monitoring observations, sampling information, and test results will be recorded on the appropriate monitoring forms, logs and/or test data sheets. The CQA Consultant will use the monitoring data sheets to check completeness of the required CQA activities. Any corrections to the monitoring data sheets will be single line crossed out, initialed by the CQA personnel responsible for the correction and dated. Examples of relevant monitoring logs are presented in Appendix A.

The CQA Consultant's monitoring forms, logs and test data sheets will include the following information as applicable:

- project specific information such as project name, location;
- the date the CQA activity was performed;
- a unique identifying sheet number for cross-referencing and document control;
- description or title of the CQA activity or test procedure;
- location of the CQA activity or location from which the sample was obtained;
- type of CQA activity or procedure used (reference to standard method when appropriate);
- recorded observation or test data, with the necessary calculations;
- results of the CQA activity and comparison with specification requirements (pass/fail); and
- the initials or signature of personnel involved in CQA inspection activity.

4.2.3 Nonconformance Identification and Reporting

A nonconformance is defined herein as material or workmanship that does not meet the specified requirement(s). Nonconformance identification and corrective measures reports will

be cross-referenced to specific summary reports, forms, logs, or test data sheets where the nonconformance was identified. The reports will include the following information as applicable:

- a unique identifying sheet number for cross-referencing and document control;
- detailed description of the problem;
- location of the problem;
- probable cause;
- how and when the problem was located;
- estimation of how long problem has existed;
- suggested corrective measures;
- documentation of corrections (reference to inspection data sheets);
- suggested methods to prevent similar problems; and
- signature of the appropriate CQA Field Monitor and concurrence by the CQA Site Manager.

In some cases, not all of the above information will be available or obtainable. However, when available, such efforts to document nonconformances could help to avoid similar nonconformances in the future. The CQA Site Manager will distribute copies of the report to the Construction Manager for further actions.

4.3 Photographic Documentation

The CQA Site Manager will be responsible for maintaining photographic documentation of the Contractor's activities, material installation methods, and testing procedures. Photographs will serve as a pictorial record of work progress, problems, and corrective measures. Photographic reporting data sheets will be utilized to organize and document photographs taken during construction of the CAMU Cover System. Such data sheets could be cross-referenced or appended to summary reports, CQA monitoring logs, or test data sheets and/or problem identification and corrective measures reports. Photographs will be organized chronologically and the digital files will be saved in a systematic manner. At a minimum, photographic reporting data sheets will include the following information:

- a unique identifying number on data sheets and photographs for cross-referencing and document control;
- person responsible for photograph;
- the date and location where the photograph was taken; and

- location and description of the work.

4.4 Design and/or Specifications Changes

Design and/or specifications changes may be required during construction. In cases of Contractor initiated changes, the Contractor must submit written requests for such changes to the Construction Manager. The Engineer will review and respond to these requests in a timely manner. The design and/or specifications changes will be made only with the approval of the Engineer.

4.5 Nonconformances

The Construction Manager will be informed in writing of any significant recurring non-conformance with the Construction Drawings, Technical Specifications, and/or this CQA Plan by the CQA Consultant. The cause of the nonconformance will be determined by the CQA Consultant. The Contractor will be directed by the Construction Manager to make appropriate changes in materials or procedures in order to correct the nonconformance. When this type of evaluation is made, the results will be documented and any revision to procedures or specifications must be approved by the Engineer.

4.6 CQA Certification Report

At the completion of construction, the CQA Consultant will provide the Owner with a construction final certification report for submittal to regulators. This report will acknowledge: (i) that the work has been performed in compliance with the final Construction Drawings, Technical Specifications, and the approved modifications; (ii) physical sampling and testing has been conducted at the appropriate frequencies; and (iii) that the summary documentation provides the necessary supporting information. At a minimum, this report will include:

- summary of CQA activities;
- CQA monitoring forms, logs and test data sheets including sample location plans;
- laboratory test results;
- problem identification and reports of corrective measures reports;
- a descriptive summary of any changes to the Construction Drawings or the Technical Specifications; and
- a summary statement indicating compliance with the Construction Drawings, Technical Specifications and any changes approved by the Engineer.

The record drawings, which include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.), and a geomembrane panel drawing will also be included as part of the final certification report.

4.7 Storage of Records

The CQA Site Manager will be responsible for the CQA document storage during the construction of the CAMU Cover System. This includes the CQA Consultant's copy of the Construction Drawings and Technical Specifications, the CQA Plan, and the originals of all data sheets and reports. When the CAMU construction is complete and upon issuance of the final certification report, the CQA document originals will be organized and retained by the CQA Consultant until requested by the Owner. Required records will include, but not be limited to, field logbooks, other data collections forms, equipment calibration records, costs data, drawings, maintenance records, and the associated reports.

5. SOILS AND GRAVELS

5.1 Introduction

CQA monitoring and testing the soil and gravel components will be performed during (i) general earthwork; (ii) construction of the liner leveling layer subbase and, soil drainage layer; and (iii) other construction activities. The criteria that will be used for evaluating the acceptability of the soil and gravel components are identified in the Technical Specifications, the Construction Drawings and this CQA Plan.

5.2 Soil and Gravel Components

There are several soil and gravel components included in the construction of the CAMU cover system. The major soil and gravel components include the following:

- 0.5-ft thick prepared subbase directly below the liner system;
- 1.5-ft thick drainage layer directly atop the geocomposite; and
- 0.5-ft thick erosion protection layer.

All fill placement, grading, and compaction will be monitored and tested in accordance with the Construction Drawings, Technical Specifications, and this CQA Plan.

5.3 Related Technical Specifications

The following sections of the Technical Specifications will be referenced by the CQA Consultant for the materials and construction requirements:

- Section 02100 - Surveying;
- Section 02200 - Earthwork; and
- Section 02235 – Granular Drainage Materials.

Prior to the start of construction, the CQA Consultant will review the information required by the Technical Specifications listed above. Compliance of the submittals with the Technical Specifications will be determined by the Engineer.

5.4 Conformance Testing

CQA Consultant will perform visual inspections and review the results of the conformance tests performed by the Contractor as part of the required CQC testing. CQA Consultant will perform conformance testing to check that the soil and gravel materials conform to the requirements in the Technical Specifications. CQA Consultant will perform conformance testing in accordance

with Table 5-1 prior to the materials being used for construction. CQA Consultant will document and report the conformance test results.

CQA personnel will observe soils and gravels for deleterious materials (e.g., roots, stumps, debris, foreign objects, etc.). Soils and gravels containing deleterious materials or failing to comply with the specified material requirements will be rejected and will not be used in construction of the CAMU.

5.4.1 Test Methods

CQA Consultant will perform the conformance tests in accordance with the current ASTM test procedures indicated in Table 5-1 to evaluate the suitability of the materials.

5.4.2 Test Frequency

CQA Consultant will perform the conformance tests at the minimum frequencies presented in Table 5-1. The frequency of testing may be increased at the discretion of the CQA Consultant or if variability of the materials is observed. Sampling locations will be selected by the CQA Consultant.

Fill material if used in other construction activities will adhere to testing frequencies described herein.

5.5 Construction Monitoring

During construction of the soil and gravel components, the CQA Consultant will observe, monitor and/or document the following:

- consistency of the materials used in construction;
- soils are conditioned as needed (moisture distribution, particle/clod size, etc.) prior to placement;
- subgrade is firm and free of vegetation, standing water or other deleterious materials;
- thickness of loose and compacted lifts meet the specified requirements;
- number of passes required to compact each lift meet the specified requirements;
- impact of compaction and hauling equipment on the construction surface (equipment penetration, pumping, cracking, etc.);
- desiccation cracks or the presence of ponded water, if any;
- placement methods prevent damage, displacement or wrinkling of the underlying geosynthetics;

- soil and gravel materials are placed, graded and compacted to the limits, grades, and elevations in compliance with the Technical Specifications and the Construction Drawings; and
- non-conforming areas are delineated and re-worked by the Contractor to meet the specified requirements; and
- damage to completed work and the associated repairs and/or re-work.

5.6 Performance Testing

During construction, the CQA Consultant will observe and test the soil and gravel components to check that installation is in accordance with the requirements of the Construction Drawings and the Technical Specifications. The CQA Consultant will conduct the performance testing in accordance with Table 5-2. CQA Consultant will document and report the performance test results. The CQA Consultant will also evaluate the procedures, methods, and equipment used by the Contractor to install the various soil and gravel components.

5.6.1 Test Methods

CQA Consultant will conduct the performance tests in accordance with the current ASTM test procedures indicated in Table 5-2 to evaluate compliance with the requirements in the Technical Specifications.

5.6.2 Test Frequency

Performance testing will be conducted during the course of the work. CQA Consultant will conduct the performance testing at the minimum frequencies presented in Table 5-2. Sampling and testing locations will be selected by the CQA Consultant.

The frequency of testing may be increased at the discretion of the CQA Consultant or when visual observations during construction indicate potential problems. The performance test frequencies may be increased in the following situations:

- lift thickness is greater than specified;
- degree of compaction is doubtful;
- materials or conditioning of the materials differ from that specified and/or tested;
- improper equipment is used or equipment is not used/operated properly;
- there is change in the condition of the completed work since approval;
- adverse weather conditions are encountered; and/or
- additional testing is required by the Engineer or the Construction Manager.

5.7 Deficiencies

If a defect is identified during construction, the CQA Consultant will immediately determine the extent and nature of the deficient materials and/or the work area by additional tests, visual observations, review of records, or other appropriate means. The CQA Consultant will notify the Construction Manager and the Contractor as soon as possible. The CQA Consultant will define the appropriate remedy and schedule appropriate re-tests and/or re-work of the deficient materials and/or the work area.

The Contractor shall remove the deficient materials and/or re-work the deficient area to the satisfaction of the CQA Consultant. CQA Consultant will verify that the Contractor has corrected the noted deficiencies. The re-tests performed by the CQA Consultant must indicate that the deficiency has been corrected before any additional work is performed by the Contractor in the area of the deficiency. If a specified criterion cannot be met, the Contractor will submit suggested solutions or alternatives to the Engineer and the Construction Manager for review and approval.

5.8 As-Built Surveys

During construction of the soil and gravel components of the CAMU, the CQA Consultant will review conformance and final as-built surveys submitted by the Contractor. The as-built surveys will be used to check the limits, grades, elevations, and/or the percentage of the work completed. Prior to the placement of successive soil or geosynthetics, the CQA Consultant will review the as-built surveys that indicate compliance of the preceding layer thickness, limits, grades and/or elevations. CQA Consultant will review the as-built surveys in a timely manner and notify the Contractor of any non-compliance.

5.9 Documentation

CQA Consultant will maintain pertinent documentation during construction of the soil and gravel components of the CAMU. The CQA monitoring observations, sample and test locations, field and laboratory test results, deficiencies identified, and the re-work or repairs performed will be documented by the CQA Consultant.

Table 5-1

**MINIMUM CONFORMANCE TESTING FREQUENCIES
FOR SOIL AND GRAVEL COMPONENTS**

Test Name/ Test Method	Subbase Fill	Soil Cover Fill	Gravel
<i>Specification Section</i>	<i>02200</i>	<i>02200</i>	<i>02235</i>
Particle Size Analysis ASTM D 6913 / C 136	1 test per 1,500 CY	1 test per 1,500 CY	1 test per 1,500 CY
Soil Classification ASTM D 2487	1 test per 1,500 CY	1 test per 1,500 CY	1 test per 1,500 CY
Permeability of Granular Soils ASTM D 2434	N/A	1 test per 1,500 CY	N/A
Direct Shear of Soils Under Consolidated Drained Conditions ASTM D 3080/ D 3080M	N/A	1 test per 1,500 CY	N/A

Notes:

1. N/R = Testing is *Not Required* as part of CQA
2. N/A = Not Applicable

Table 5-2

**MINIMUM PERFORMANCE TESTING FREQUENCIES
FOR SOIL AND GRAVEL COMPONENTS**

Test Name/ Test Method	Subbase Fill	Soil Cover Fill	Gravel
<i>Specification Section</i>	<i>02200</i>	<i>02200</i>	<i>02235</i>
Standard Proctor ASTM D 698	1 test per 3,000 CY ⁽¹⁾	1 test per 3,000 CY ⁽¹⁾	N/A
In-Situ Moisture ASTM D 6938 or D 2216	10 tests per lift per acre or 2 tests per lift per 100 LF ⁽¹⁾	10 tests per lift per acre or 2 tests per lift per 100 LF ⁽¹⁾	N/A
In-Situ Density ASTM D 6938/D 1556/D 2937	10 tests per lift per acre or 2 tests per lift per 100 LF ⁽¹⁾	10 tests per lift per acre or 2 tests per lift per 100 LF ⁽¹⁾	N/A
Interface Friction Angle ASTM D 5321 and/or ASTM D 6243	N/A	10 tests per lift per acre or 2 tests per lift per 100 LF ⁽¹⁾	N/A

Notes:

1. CQA Consultant will conduct 1 performance test for every 25 performance tests conducted by the Contractor.
2. N/A = Not Applicable

6. GEOMEMBRANE

6.1 Introduction

CQA Consultant will perform conformance and destructive seam testing and will monitor the installation of geomembranes in compliance with the requirements of Section 02770 of the Technical Specifications and this CQA Plan. CQA Consultant will perform the tests indicated in Tables 6-1 and 6-2 in accordance with the current versions of the ASTM or the noted test procedure.

6.2 Manufacturing Plant Visit

At the request of the Owner, the CQA Consultant or an authorized representative may visit the plant of the Geomembrane Manufacturer for the purpose of collecting conformance samples and to check that the manufacturing quality control procedures are in conformance with the Technical Specifications. The CQA Consultant will review the manufacturing process, quality control procedures, laboratory facilities, and the testing procedures.

6.3 Transportation, Handling and Storage

CQA Consultant will monitor the transportation, handling, and storage of the geomembrane on-site. The Construction Manager will designate a geomembrane storage location. It will be the responsibility of the Contractor to protect the geomembrane stored on site from damage, theft, and/or vandalism.

Upon delivery at the site, the Contractor, Installer, and CQA Consultant will conduct an inspection of the rolls for defects and damage. This inspection will be conducted without unrolling the materials unless defects or damages are found or suspected. The CQA Consultant will indicate to the Construction Manager:

- rolls, or portions thereof, which should be rejected and removed from the site because they have severe or non-repairable flaws which may compromise geomembrane quality; and
- rolls that include minor and repairable flaws that do not compromise geomembrane quality.

CQA Consultant will also monitor that the equipment used to handle the geomembrane on-site is appropriate and does not pose any risk of damaging the geomembrane when used properly.

6.4 Conformance Testing

6.4.1 Sampling Procedures

CQA Consultant will collect representative geomembrane conformance samples from rolls that will be used for the project at the specified frequency and forward the samples to the

Geosynthetics CQA Laboratory for testing. Geomembrane conformance samples will be taken across the entire width of the roll and will not include the first 3 ft of material. Unless otherwise directed by the Engineer, samples will be 3 ft long by the roll width. The required minimum geomembrane conformance sampling frequencies are provided in Table 6-1. The CQA Consultant will mark the machine direction on the samples with an arrow and include the following information for each sample:

- date sampled;
- project number;
- lot/batch number and roll number;
- conformance sample number; and
- CQA personnel identification.

6.4.2 Testing Procedures

Conformance testing of the geomembrane will be conducted to evaluate compliance with the Technical Specifications. As a minimum, the geomembrane conformance tests listed in Table 6-1 will be performed by the CQA Consultant.

6.4.3 Test Results

The conformance test results will be reviewed, accepted, and reported by the CQA Consultant before deployment of the geomembrane. The test results will be reviewed to check that they meet or exceed the material requirements included in the Technical Specifications. Any non-conformance of the material's properties with the requirements of the Technical Specifications will be reported to the Construction Manager.

6.4.4 Conformance Test Failure

In the case of failing test results, the Contractor may request that another sample from the failing roll be re-tested by the CQA Consultant. If the re-test fails or if the option to re-test is not exercised, then two isolation conformance samples will be obtained by the CQA Consultant. These isolation samples will be taken from rolls, which have been determined by correlation with the manufacturer's roll number, to have been manufactured prior to and after the failing roll. This method for choosing isolation rolls for testing will continue until passing tests are achieved. All rolls that fall numerically between the passing roll numbers will be rejected. The CQA Consultant will verify that the Contractor has replaced all rejected rolls. The CQA Consultant will document the actions taken in conjunction with geomembrane conformance failures.

6.5 Anchor Trench

The CQA Consultant will monitor and document that the anchor trench has been constructed as indicated in the Construction Drawings. The amount of anchor trench open at any time will be

limited to one day of geomembrane installation capacity. Ponding of water will not be allowed in the anchor trench.

Geosynthetic materials in the anchor trench will be temporarily anchored with sand bags or other suitable methods approved by the CQA Consultant. The anchor trench will be backfilled with suitable material as indicated in the Construction Drawings and Technical Specifications as soon as possible after the geosynthetics are installed. In-place moisture/density testing of the compacted anchor trench backfill will be in accordance with the requirements in the Technical Specifications and this CQA Plan.

The anchor trench will be constructed with a slightly rounded corner where the geosynthetics enter the trench. No loose soil will be allowed to underlie the geosynthetics in the anchor trench. The CQA Consultant will monitor that all temporary ballast (i.e., sandbags) and deleterious materials are removed from the anchor trench prior to backfilling. Backfilling of the anchor trench will be performed when the geomembrane is in its most contracted state to prevent stress inducement and using extreme care to prevent any damage to the geosynthetic materials.

6.6 Geomembrane Placement

6.6.1 Field Panel Identification

A field panel is a piece of geomembrane larger than approximately 10 ft², which is to be seamed in the field, i.e., a field panel is a roll or a portion of roll cut in the field. The CQA Consultant will monitor that each field panel is given an "identification code" (number or letter-number) consistent with the as-built layout plan. This identification code will be agreed upon by the Installer and CQA Consultant. This field panel identification code will be as simple and logical as possible. The geosynthetic Manufacturer's roll numbers will be traceable to the field panel identification code.

The CQA Consultant will document the correspondence between roll numbers, factory panels, and field panel identification codes. The field panel identification code will be used for all quality assurance/quality control records.

6.6.2 Field Panel Placement

The CQA Consultant will monitor that field panels are installed substantially at the location indicated in the Installer's layout plan, as approved or modified. The CQA Consultant will record the field panel identification code, Manufacturer's roll number, location, date of installation, time of installation, and dimensions of each field panel.

Geomembrane placement will not proceed at an ambient temperature below 40°F or above 104°F unless authorized by the Engineer. Geomembrane placement will not proceed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds. The CQA Consultant will monitor that the above conditions are fulfilled and the underlying soil has not been damaged during geomembrane placement.

The CQA Consultant will monitor geomembrane deployment for the following:

- equipment used does not damage the geomembrane due to handling, trafficking, excessive heat, leakage of hydrocarbons or other means;
- prepared surface underlying the geomembrane is acceptable immediately prior to the geomembrane placement and has not been damaged or deteriorated since previous acceptance;
- personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities that could potentially damage the geomembrane;
- method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the underlying soil;
- the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);
- adequate temporary loading and/or anchoring (sand bags or tires that are not likely to damage the geomembrane) has been placed to prevent uplift by wind (continuous loading along the edges of the panels is recommended to minimize risk of wind flow under the panels); and
- direct contact with the geomembrane is minimized in areas where excessive traffic is expected, i.e., the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials.

The CQA Consultant will observe the geomembrane panels for damage after placement and prior to seaming. The CQA Consultant will inform the Contractor if any panels or portions of panels need to be repaired or are rejected. Repairs will be made according to procedures described in this Section. Damaged panels or portions of damaged panels that have been rejected will be marked and their removal from the work area will be recorded by the CQA Consultant.

6.7 Field Panel Seaming

6.7.1 Panel Layout

The CQA Consultant will review the panel layout drawing previously submitted by the Installer and check that it is consistent with accepted state of practice. In general, seams should be oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be within 10 ft of the toe or shoulder of the slope, or in areas of potential stress concentrations, unless otherwise authorized by the Engineer. A seam numbering system compatible with the field panel identification numbering system will be agreed upon prior to any seaming.

6.7.2 Seaming Equipment and Products

Approved processes for field seaming are extrusion welding and fusion welding. Proposed alternate processes will be documented and submitted to the Engineer for approval. Only equipment that has been specifically recommended by the geosynthetics Manufacturer (by make and model) will be used. All seaming equipment will be permanently marked with an identification number.

6.7.2.1 Fusion Process

The fusion-welding apparatus must be automated, self-propelled devices. The fusion-welding apparatus will be equipped with gauges to indicate the temperature and the welding speed. The CQA Consultant will monitor ambient temperature, geomembrane surface temperature, apparatus speed, and apparatus temperature at regular intervals.

The CQA Consultant will also monitor that:

- number of spare operable seaming apparatus agreed by the Construction Manager are maintained on site;
- equipment used for seaming does not damage the geomembrane;
- seaming zone is dry and clean;
- sufficient overlap is provided between panels;
- electric generator is placed on a smooth base such that no damage occurs to the geomembrane;
- for cross seams, the edge of the cross seam is ground to a smooth incline (top and bottom) prior to welding;
- an insulating material is placed beneath the hot welding apparatus after usage; and
- a movable protective layer is used, as necessary, directly below each overlap of geomembrane that is to be seamed to prevent build-up of moisture between the sheets.

6.7.2.2 Extrusion Process

The extrusion-welding apparatus will be equipped with gauges indicating the temperature in the apparatus and at the nozzle. The CQA Consultant will check that the extrudate is comprised of the same resin as the geomembrane sheeting. The CQA Consultant will monitor extrudate temperatures, ambient temperatures, and geomembrane surface temperatures at regular intervals.

The CQA Consultant will also monitor that:

- number of spare operable seaming apparatus agreed by the Construction Manager are maintained on site;
- equipment used for seaming does not damage the geomembrane;
- seaming zone is dry and clean;
- extruder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel;
- electric generator is placed on a smooth base such that no damage occurs to the geomembrane; and
- an insulating material is placed beneath the hot welding apparatus after usage.

6.7.3 Seam Preparation

The CQA Consultant will monitor that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;
- seams are overlapped a minimum of 4 inches;
- if seam overlap grinding is required, the process is completed according to the geosynthetics Manufacturer's instructions or the Technical Specifications, whichever is more stringent, prior to the seaming operation, and in a way that does not damage the geomembrane;
- grind depth does not exceed 10 percent of the geomembrane thickness;
- grinding marks will not appear beyond the extrudate after it is placed; and
- seams are aligned with the fewest possible number of wrinkles and "fishmouths".

6.7.4 Weather Conditions for Seaming

The normally required weather conditions for seaming are as follows:

- Unless authorized by the Engineer, no seaming will be attempted at an ambient temperature below 40°F or above 104°F.
- Between ambient temperatures of 40°F and 50°F, seaming is possible if the geomembrane is pre-heated by either sun or hot air device, and if there is no cooling of the geomembrane to below 50°F resulting from wind.
- In all cases, the geomembrane seam areas will be dry and protected from rain and

wind.

The CQA Consultant will check that methods used by the Installer for seaming at ambient temperatures below 40°F or above 104°F will produce seams that are entirely equivalent to seams produced at ambient temperatures between 40°F and 104°F and protect the overall quality of the geomembrane. The CQA Consultant will monitor that seaming conducted during abnormal weather conditions is performed in accordance with the methods approved by the Engineer.

6.7.5 Overlapping and Temporary Bonding

The CQA Consultant will monitor that:

- panels of geomembrane have sufficient overlap to allow peel tests to be performed on the seam;
- no solvent or adhesive is used; and
- the procedure used to temporarily bond adjacent panels together does not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any spot welding apparatus is controlled such that the geomembrane is not damaged.

6.7.6 Trial Seams

CQA Consultant will check that the Installer performs trial seam tests in accordance with the Technical Specifications. The CQA Consultant will observe and document the Installer's trial seam testing procedures. The trial seam samples will be assigned an identification number and marked accordingly by the CQA Consultant. Each sample will be marked with the date, time, machine temperature(s) and setting(s), number of seaming unit, and name of the seaming technician. Trial seam samples will be maintained until destructive seam testing of the applicable seams are tested and pass.

6.7.7 General Seaming Procedures

No geomembrane seaming will be performed unless the CQA Consultant is on-site. CQA Consultant will monitor the general seaming procedure used by the installer as follows:

- During fusion welding, a movable protective layer of plastic is placed directly below each overlap of geomembrane that is to be seamed, if required. This is to prevent any moisture build-up between the sheets to be welded.
- A firm substrate is provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support, if required.
- Fishmouths or wrinkles at the seam overlaps are cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles are seamed and any portion where the overlap is inadequate is patched with an oval or round patch of the

same geomembrane extending a minimum of 6 inches beyond the cut in all directions.

- Seaming extends to the outside edge of panels to be placed in the anchor trench.

6.7.8 Non-Destructive Seam Continuity Testing

The CQA Consultant will monitor that the Installer will non-destructively test all field seams over their full length using a vacuum test unit or air pressure test (for double fusion seams only) as specified in Table 6-2. Spark testing may be performed if the seam cannot be tested using the vacuum or air pressure test methods. The purpose of non-destructive tests is to check the continuity of seams. Seam continuity testing will be carried out as the seaming work progresses, not at the completion of all field seaming. The CQA Consultant will:

- monitor non-destructive testing;
- document the results of the non-destructive testing; and
- inform the Contractor and Construction Manager of any non-compliance.

Any required seam repairs will be made in accordance with the Technical Specifications. The CQA Consultant will:

- observe the repair procedures;
- observe the re-testing procedures; and
- document the results.

The seam number, date of observation, dimensions and/or descriptive location of the seam length tested, name of person performing the test, and the outcome of the test will be recorded by the CQA Consultant.

6.7.9 Destructive Testing

Destructive seam testing will be performed during the geomembrane installation. The purpose of the testing is to evaluate the seam strength. Destructive seam testing will be done as the seaming work progresses, not at the completion of all field seaming.

6.7.9.1 Frequency and Location

The CQA Consultant will select all destructive seam test sample locations. Sample locations will be established as follows:

- Destructive seam testing will be performed at the minimum frequency specified in Table 6-2. This minimum frequency represents an average for the entire cap. Additional samples may be collected for seams made outside the normal ambient temperature range of 40°F to 104°F.

- Test locations will be selected by the CQA Consultant during seaming. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding. The Installer will not be informed in advance of the locations where the seam samples will be taken.

6.7.9.2 Sampling Procedures

Destructive seam testing will be performed as the seaming progresses in order to obtain the seam strength test results before the geomembrane is covered by the overlying materials. The CQA Consultant will:

- observe sample cutting;
- assign a number to each sample, and mark it accordingly; and
- record sample location on geomembrane panel layout drawing.

All holes in the geomembrane resulting from destructive seam test sampling will be immediately repaired in accordance with repair procedures described in the Technical Specifications. The continuity of the new seams in the repaired area will be non-destructively tested as described in this Section.

6.7.9.3 Size of Samples

At a given sampling location, two types of samples (field test samples and laboratory test samples) will be taken. First, a minimum of two field samples or test strips should be taken for field testing. Each of these test strips will be 1-inch wide by 12-inch long, with the seam centered parallel to the width. The distance between these two specimens will be 42 inches. If both specimens pass the field test, a second full laboratory destructive sample will be taken for testing by the Geosynthetics CQA Laboratory.

The full destructive sample will be located between the two field test strips. The sample will be 12-inch wide by 42-inch long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:

- one 12 inch by 12 inch portion to the Installer;
- one 12 inch by 12 inch portion to the Engineer for archive storage; and
- one 12 inch by 18 inch portion for Geosynthetics CQA Laboratory testing.

6.7.9.4 Field Testing

The test strips will be tested in the field for peel adhesion using a gauged tensiometer. In addition to meeting the strength requirements outlined in the Technical Specifications, all specimens will exhibit a Film Tear Bond (FTB) and will not fail in the weld as noted in Table 6-2.

If any field test sample fails to meet these requirements, that destructive sample will be considered as failed.

The CQA Consultant will witness the field tests and mark all samples and portions with their number. The CQA Consultant will also log the date, number of the seaming unit, seaming technician identification, destructive sample number, and pass or fail description.

6.7.9.5 Geosynthetics CQA Laboratory Testing

Destructive test samples will be tested by the Geosynthetics CQA Laboratory. Testing will include "Bonded Seam Strength" and "Peel Adhesion" (ASTM D 6392). The minimum requirements for these tests are included in the Technical Specifications and in Table 6-2. At least five specimens will be tested for each test method. Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear...). Both the inside and outside tracks of the double track fusion seams will be tested for peel adhesion. A passing test will meet the minimum requirements in the Technical Specifications and in Table 6-2.

The Geosynthetics CQA Laboratory will provide test results no more than 24 hours after they receive the samples. The CQA Consultant will review laboratory test results as soon as they become available and make appropriate recommendations to the Construction Manager.

6.7.9.6 Procedures for Destructive Test Failure

The following procedures will apply whenever a sample fails a destructive test, whether that test was conducted in the field or by the Geosynthetics CQA Laboratory. The CQA Consultant will monitor that the Installer follows one of the two options below:

- The Installer can re-construct the seam (e.g., remove the old seam and re-seam) between any two passed destructive test locations or between points judged by the CQA Consultant to represent conditions of the failed seam (e.g., a tie-in seam or a seam made by the apparatus and/or operator used in the failing seam); or
- The Installer can trace the welding path to an intermediate location a minimum of 10 ft from the point of the failed test in each direction and take a small sample for additional field testing in accordance with the destructive test procedure at each location. If these additional isolation samples pass the field test, then full laboratory samples are taken at both locations. If these laboratory samples meet the specified strength criteria, then the seam is reconstructed between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed or repaired.

All failed seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken or the entire seam is re-constructed and re-tested. In cases exceeding 150 ft of reconstructed seam, a sample taken from the zone in which the seam has been reconstructed must be tested and pass the destructive testing. Repairs will be made in accordance with this Section. The CQA Consultant will document the actions taken in conjunction with destructive test failures.

6.8 Defects and Repairs

6.8.1 Identification

All seams and non-seam areas of the geomembrane will be examined by the CQA Consultant for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be clean at the time of examination. The CQA Consultant will require the geomembrane surface to be broomed or washed by the Contractor if the amount of dust or mud inhibits examination.

6.8.2 Repair Procedures

Any portion of the geomembrane exhibiting a flaw or failing a destructive or non-destructive test will be repaired by the Geosynthetics Installer in accordance with the Technical Specifications. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure will be agreed upon between the Installer and the CQA Consultant.

In addition, the following conditions will be monitored by the CQA Consultant:

- surfaces of the geomembrane that have to be repaired are abraded no more than one hour prior to the repair;
- all surfaces are clean and dry at the time of the repair;
- seaming equipment performing passing seams is used for repairs;
- the repair procedures, materials, and techniques are approved by the CQA Consultant in advance of the specific repair;
- patches or caps extend at least 6 inches beyond the edge of the defect, and all corners of patches are rounded with a radius of at least 3 inches; and
- the geomembrane below large caps is appropriately cut to avoid water or gas collection between the two sheets.

6.8.3 Verification of Repairs

Each repair will be numbered and logged. Each repair will be non-destructively tested using approved methods. Repairs that pass the non-destructive test will be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive test sampling as specified in Section 6.7.9.6 or at the discretion of the CQA Consultant. The CQA Consultant will observe all non-destructive testing of repairs and will record the number of each repair, date, and the test outcome.

6.9 Liner System Acceptance

The Contractor will retain all responsibility for the geosynthetics until acceptance by the Construction Manager. The terms for the liner acceptance are described in the Technical Specifications.

6.10 Materials in Contact with the Geomembrane

The procedures outlined in this Section are intended to prevent damage during installation of materials that are in contact with the geomembrane.

6.10.1 Soils

The CQA Consultant will monitor that the Contractor takes all necessary precautions not to damage the geomembrane during the construction activities. The CQA Consultant will monitor the following:

- placement of the geocomposite drainage layer above the geomembrane which will not proceed at an ambient temperature below 40°F or above 104°F unless otherwise approved by the Engineer;
- geocomposite drainage layer placement operations above the geomembrane will be performed by the Contractor to minimize wrinkles in the geomembrane;
- equipment used for placing soil will not be driven directly on the geomembrane and the ground pressure on geomembrane does not exceed that specified in Section 02770 of the Technical Specifications;
- a minimum soil thickness of 1 foot is maintained between a light, track-mounted dozer (e.g., having a maximum ground pressure of 5 psi) and the geomembrane;
- soil thickness will be greater than 3 feet in heavily trafficked areas such as access ramps;
- on side slopes, material is placed over the geomembrane from bottom of the slope upward; and
- geomembrane is covered with overlying soils and gravel within 15 days.

6.10.2 Appurtenances

The CQA Consultant will monitor that:

- installation of the geomembrane in appurtenant areas and connection of geomembrane to appurtenances, if any, have been made in accordance with the Construction Drawings and Technical Specifications;

- extreme care is taken by the Installer when seaming around appurtenances since neither non-destructive nor destructive testing may be feasible in these areas; and
- the geomembrane has not been visibly damaged when making connections to the appurtenances.

TABLE 6-1

**GEOMEMBRANE CONFORMANCE
TESTING REQUIREMENTS**

Test Name	Test Method	Minimum Testing Frequency
Specific Gravity	ASTM D 792 Method B or ASTM D 1505	1 test per 60,000 ft ²
Thickness	ASTM D 5994	1 test per 30,000 ft ²
Tensile Strength at Yield	ASTM D 6693 (Type IV)	1 test per 30,000 ft ²
Tensile Strength at Break	ASTM D 6693 (Type IV)	1 test per 30,000 ft ²
Elongation at Yield	ASTM D 6693 (Type IV)	1 test per 30,000 ft ²
Elongation at Break	ASTM D 6693 (Type IV)	1 test per 30,000 ft ²
Carbon Black Content	ASTM D 4218	1 test per 60,000 ft ²
Carbon Dispersion	ASTM D 5596	1 test per 60,000 ft ²
Interface Shear Strength ⁽²⁾	ASTM D 5321	1 test per cell

Notes:

1. At least one test will be performed for each resin lot (resin lot as defined by ASTM D 4354).
2. Interface shear strength test will be performed in accordance with the requirements outlined in Section 02790 of the Technical Specifications.

Table 6-2

**GEOMEMBRANE SEAM
TESTING REQUIREMENTS**

Test Name	Test Method	Minimum Testing Frequency
Peel Strength	ASTM D 6392 ^(1,3)	1 test every 500 ft ⁽⁴⁾
Shear Strength	ASTM D 6392 ^(2,3)	1 test every 500 ft ⁽⁴⁾
Vacuum Testing Welded Seams	--	100% of extrusion welds
Air Pressure Testing Welded Seams	--	100% of fusion welds

Notes:

1. For peel adhesion, seam separation will not extend more than 10 percent into the seam interface. Testing will be discontinued when the sample has visually yielded.
2. For shear tests, the sheet will yield before failure of the seam.
3. For either test, sample failure will be a Film Tear Bond (FTB).
4. Since the area of the cell is small, Engineer may request a higher frequency depending on the final panel layout.

7. GEOTEXTILES

7.1 Introduction

CQA Consultant will monitor the installation of geotextile as required by the Construction Drawings and this CQA Plan. Geotextile will be used as a cushion between the gravel and the geomembrane. The CQA Consultant will confirm that the geotextile proposed by the Contractor is GSE NW8 nonwoven needle punched geotextile or equivalent. Conformance testing will not be performed for the geotextile due to the non-critical nature of its use.

7.2 Transportation, Handling, and Storage

CQA Consultant will monitor the transportation, handling, and storage of the geotextile on-site. The Construction Manager will designate a geotextile storage location. During transportation, handling, and storage, the geotextile will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

Handling of the geotextile rolls will be performed in a competent manner such that damage does not occur to the geotextile or to its protective wrapping. Rolls of geotextiles will not be stacked upon one another to the extent that deformation of the core occurs or to the point where accessibility can cause damage in handling. Furthermore, geotextile rolls will be stacked in such a way that access for conformance sampling, if needed, is possible. Protective wrappings will be removed less than one hour prior to unrolling the geotextile. After unrolling, a geotextile will not be exposed to ultraviolet light for more than 30 calendar days.

Outdoor storage of geotextile rolls will not exceed the Manufacturers recommendations or 6 months, whichever is less. For storage periods longer than 6 months, a temporary enclosure will be placed over the rolls or they will be moved to an enclosed facility. The location of temporary field storage will not be in areas where water can accumulate. The rolls will be elevated off the ground to prevent contact with ponded water.

Upon delivery at the site, the Contractor, Installer, and CQA Consultant will conduct an inspection of the rolls for defects and damage. This inspection will be conducted without unrolling the materials unless defects or damages are found or suspected. The CQA Consultant will indicate to the Construction Manager:

- rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and
- rolls which include minor repairable flaws.

CQA Consultant will also monitor that the equipment used to handle the geotextiles on-site is adequate and does not pose any risk of damage to the geotextiles when used properly.

7.3 Placement

CQA Consultant will monitor the placement of all geotextiles to check they are not damaged in any way, and the following installation requirements are met.

- On slopes, the geotextiles are deployed down the slope in a manner that continually keeps the geotextile in tension.
- In the presence of wind, the geotextiles are weighted with sandbags or equivalent. Such sandbags will be installed during placement and will remain until replaced with overlying material (stone or gravel).
- Trimming of the geotextiles will be performed using only an upward cutting hook blade. Special care must be taken to protect other materials from damage which could be caused by the cutting of the geotextiles.
- CQA Consultant will monitor that the Installer is taking necessary precautions to prevent damage to underlying layers during placement of the geotextile.
- After installation, a visual examination of the geotextile will be carried out over the entire surface to check that no potentially harmful foreign objects, (e.g., stones, sharp objects, small tools, sandbags, etc.) are present.

7.4 Seams and Overlaps

The geotextile may be sewn or overlapped. Geotextiles will be overlapped 6 inches prior to seaming. No horizontal seams will be allowed on side slopes that are steeper than 10 horizontal to 1 vertical (i.e. seams will be along, not across, the slope), except as part of a patch. Sewing will be done using polymeric thread with chemical and ultraviolet resistance properties equal to or exceeding those of the geotextile. The seams will be sewn using a single row type "401" two-thread chain stitch.

Geotextile may be overlapped a minimum of 2 feet in lieu of sewing. The CQA Consultant will monitor the geotextile seaming procedures to check that seams and overlaps are in accordance with this CQA Plan.

7.5 Repairs

CQA Consultant will monitor that any holes or tears in the geotextile are repaired as follows:

- On-slopes: A patch made from the same geotextile is double seamed into place (with each seam 1/4 inch to 3/4 inch apart and no closer than 1 inch from any edge) with a minimum 12-inch overlap. Should any tear exceed 50 percent of the width of the roll, that roll will be removed from the slope and replaced.
- Non-slopes: A patch made from the same geotextile is sewn in place with a minimum of 12 inch overlap in all directions away from the repair area.

Care will be taken to remove any soil or other material which may have penetrated the torn geotextile. The CQA Consultant will observe all repairs to monitor compliance with the above repair requirements.

7.6 Placement of Materials

CQA Consultant will monitor the Contractor's placement of all materials (stone or gravel) on top of a geotextile, to check:

- that no damage occurs to the geotextile;
- that no shifting of the geotextile from its intended position occurs and underlying geomembrane is not damaged;
- that excess tensile stress does not develop in the geotextile; and
- that equipment ground pressure on geotextiles overlying geomembrane does not exceed that specified in Section 02770 of the Technical Specifications.

Covering of the geotextile with gravel or stone will be completed within 15 days. On side slopes, stone will be placed over the geotextile from the bottom of the slope upward.

8. GEOSYNTHETIC DRAINAGE LAYER

8.1 Introduction

CQA Consultant will monitor the installation of the geocomposite drainage layer (GDL) in conformance with the requirements of Section 31 05 19 of the Technical Specifications and this CQA Plan. Routine testing of the material properties will not be conducted.

8.2 Transportation, Handling, and Storage

Upon delivery of the GDL to the site, the Contractor, Installer, and CQA Consultant will conduct an inspection of the rolls for defects and damage. This inspection will be conducted without unrolling the materials unless defects or damages are found or suspected. The CQA Consultant will indicate to the Construction Manager:

- rolls, or portions thereof, which should be rejected and removed from the site because they have severe defects or damages; and
- rolls which include minor repairable defects or damage.

The CQA Consultant will also monitor that equipment used to handle the GDL on-site is adequate and does not pose any risk of damage to the GDL when used properly.

8.3 Record

CQA Consultant will record the lot/batch number and roll number for each roll of material delivered.

8.4 Surface Preparation

The CQA Consultant and the Installer will jointly check that the surface on which the GDL will be installed is acceptable. The CQA Consultant will notify the Contractor of any observed soil/geomembrane condition that may require repair work and check that repair work is completed.

8.5 Placement

The CQA Consultant will monitor that the GDL rolls are handled in a manner to prevent damage and that the following installation requirements are met:

- GDL rolls are weighted down using sandbags or the equivalent methods;
- on slopes, GDL is deployed in a manner to continually keep it under tension to minimize wrinkles;
- GDL is cut in a manner recommended by the Manufacturer;

- fugitive stones or other debris are not to be entrapped under the GDL rolls during placement;
- exposed GDL is protected from damage in heavily trafficked areas;
- a visual examination of the GDL after installation to check for damaged areas, if any, are identified and repaired; and
- if a white colored GDL is used, precautions are taken against “snow blindness” of personnel.

8.6 Overlaps

CQA Consultant will monitor and check the GDL overlapping procedures conform to the requirements of the Technical Specifications.

8.7 Repairs

CQA Consultant will monitor the repair of any holes or tears in the GDL. Repairs will be made by placing a patch made from the same type GDL over the damaged area. On slopes greater than 5 percent, the patch will overlap the edges of the hole or tear by a minimum of 2 feet in all directions. On slopes, 5 percent or flatter, the patch will overlap the edges of the hole or tear by a minimum of 1 foot in all directions. The patch will be secured to the satisfaction of the CQA Consultant to avoid shifting during placement of soil or other geosynthetics.

9. PIPES AND FITTINGS

9.1 Introduction

CQA Consultant will monitor the installation of pipes and fittings in the gas collection systems in accordance with Sections 02715 of the Technical Specifications, the Construction Drawings and this CQA Plan.

9.2 Butt-Fusion Welding Process

CQA Consultant will monitor the assembling of lengths of HDPE pipe into suitable installation lengths by the butt-fusion process. Butt-fusion means the butt-joining of the pipe by softening the aligned faces of the pipe ends in a suitable apparatus and pressing them together under controlled pressure. Butt-fusion welding of the HDPE pipes and fittings will be performed by the Contractor in accordance with the pipe manufacturer's recommendations for the equipment and the fusion technique.

9.3 Transportation, Handling, and Storage

The pipe will be bundled together with plastic straps for bulk handling and shipment. The packing will be such that appropriate equipment with slings can be used for safe handling. The pipe will be segregated by wall thickness and diameter.

The CQA Consultant will monitor the offloading of the pipe to check that handling is performed in a competent manner and that the pipes are not placed in areas where water/dirt can accumulate. The pipe will be placed off the ground and will not be stacked more than three high or in a manner that could cause damage to the pipes. Furthermore, the pipe will be stacked in a manner that access for any conformance sampling, if needed, is possible. Outdoor storage shall not exceed 12 months. For outdoor storage periods longer than 12 months, a temporary covering will be placed over the pipes, or they will be moved inside an enclosed facility.

9.4 Installation

CQA Consultant will monitor the installation of the pipes and check that the workmanship conforms to the state-of-practice. Contractor will install the pipe and fittings in a manner that they are not cut, kinked, or otherwise damaged. Ropes, fabric, or rubber-protected slings and straps will be used by the Contractor when installing pipes. The use of chains, cables, or hooks inserted into the pipe ends will not be allowed.

Slings for handling the pipe will not be positioned at butt-fused joints of HDPE pipes. Sections of the pipes with deep cuts and/or gouges will be removed and the ends of the pipeline rejoined. Care will be exercised to prevent damage or twisting of the pipes during installation.

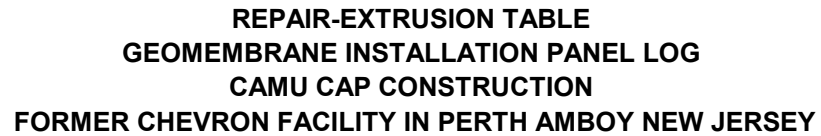
9.5 Materials

CQA Consultant will check that the pipes and fittings meet the requirements in the Technical Specifications.

APPENDIX A

CQA FORMS AND LOGS

CAMU Cap Inspection Form			Notes
Site/Cap Location (AOC or SWMU and Yard)			
Date/Time of Inspection			
Name of Inspector			
Weather (temperature, wind speed, wind direction, precipitation)			
Photograph ID			
Cap Condition/ Visual Inspection	Integrity of Cap	Evidence of human activities?	
		Evidence of burrowing animals?	
		Evidence of plant root growth?	
		Evidence of erosion?	
		Evidence of exposed contaminated soil?	
		Evidence of vandalism?	
	Any evidence of differential settlement of the cap?		
	Is there a need to repair or replenish the cap?		
Access	Is there sufficient access to capped areas?		
Monitoring	Does the cap currently meet the approved engineering conditions?		
Additional Notes			



Notes

1) Location of the repairs, panel numbers and corresponding roll numbers are indicated on the as-built geomembranepanel layout in Figure X

2) Vacuum testing of the extrusion welding conducted at the repair locations was performed by AEG's technician and witnessed by the QA Engineer.

SECTION 02100

SURVEYING

PART 1 GENERAL

1.01 SCOPE

This section describes the requirements for surveying during construction and to prepare the “as-built” documents.

1.02 REFERENCES

- A. National Geodetic Survey Standards.

1.03 SUBMITTALS

- A. Contractor shall provide the Engineer with interim surveys upon request by the Engineer. Contractor may be required to submit survey notes during construction upon request by the Engineer.
- B. Upon completion of the work, the Contractor shall submit survey field notes, drawings or sketches, layouts, computations, and electronic files to the Engineer.
- C. Contractor shall complete and submit conformance as-built surveys within 14 days of completion of a construction activity.
- D. Contractor shall submit final record as-built surveys (signed and stamped by a State of New Jersey Licensed/Registered Land Surveyor or Professional Engineer) to the Engineer within 30 days of completion of a construction activity.

1.04 PROJECT RECORD DOCUMENTS

- A. Contractor shall maintain on-site a complete survey log documenting the survey work performed.
- B. Contractor shall maintain on-site a plan clearly showing all site reference points, survey control points, and benchmarks.

- C. Contractor shall maintain on-site a current set of drawings indicating the as-built conditions.
- D. Contractor shall complete and submit conformance as-built surveys within 14 days of completion of a construction activity. As a minimum, conformance as built surveys shall be provided for cap liner system.
- E. Final record as-built surveys signed and stamped by a State of New Jersey Licensed/Registered Land Surveyor or Professional Engineer shall be submitted within 30 days of completion of a construction activity. As a minimum, final record as-built surveys shall be provided for limits and top of liner subbase (top of base grade on which geosynthetics will be installed) and for limits and top of liner protective or erosion protection stone cover.

PART 2 PRODUCTS

2.01 MATERIALS AND SURVEY EQUIPMENT

- A. Provide materials and survey equipment as required to properly perform the surveys, including, but not limited to, instruments, tapes, rods, measures, mounts, and tripods, stakes and hubs, nails, ribbons, other reference markers, and all other materials as needed.
- B. The survey instruments used for this work shall be precise and accurate to meet the needs of the work described. All survey instruments should be capable of reading to a precision of 0.01 ft and with a setting accuracy of ± 0.8 seconds.

PART 3 EXECUTION

3.01 GENERAL

- A. Survey notes and information shall be written and maintained. A copy of the survey notes shall be provided to the Engineer upon request to check the work.
- B. During construction, survey notes shall be retained by the Contractor and shall be submitted to the Engineer for review upon request. Prior to the placement of the geosynthetics, the Contractor shall submit an as-built survey of the base grades to the Engineer and certify compliance of the base grades with the Construction Drawings. The Contractor shall allow the CQA Consultant and/or Engineer at least three calendar days for review.

- C. Conformance check surveys for elevation and for horizontal coordinates shall be to the nearest 0.1 ft and for angles shall be to the nearest 20 seconds.
- D. Slope stakes shall be set in accordance with accepted surveying practices.
- E. Grade stakes required for construction activities shall be set as the work progresses. Fine grade stakes shall be set on all items for which the Construction Drawings specify a definite grade line.
- F. Upon completion of the work, the Contractor shall provide the Engineer with survey field notes, drawings or sketches, layouts, computations, and electronic files. The electronic file information shall be compatible with the Engineer's computer equipment and software. The Contractor shall allow the Engineer three calendar days for review.
- G. Survey control points shall be protected and survey control points that are disturbed or destroyed shall be replaced at no additional cost to the Owner.
- H. Perform construction layout surveys in advance of scheduled construction activities. The Contractor is responsible for rework and/or construction delays caused by survey or staking errors.

3.02 SPECIFIC FIELD REQUIREMENTS

- A. Establish temporary control points, as necessary, to support the construction activities.
- B. Survey Documentation:
 - 1. Record the following information in survey notebooks for each control point established:
 - a. control point designation;
 - b. northing and easting in State Plane North American Datum (NAD83);
 - c. elevation in National Geodetic Vertical Datum (NGVD29);
 - d. date of establishment;
 - e. description and sketch of the control point location; and
 - f. a minimum of three reference features that can be seen from the control point.
 - 2. Document the following information for the survey work:
 - a. legend indicating symbols used in survey notes;
 - b. names of survey team for each task;
 - c. notes on weather and equipment;
 - d. date and time to indicate when work was recorded;

- e. notes in a uniform character such that they can be interpreted and used by anyone with survey knowledge; and
- f. description and/or sketches of the survey control used.

C. Preliminary Surveys:

- 1. Earthwork Staking: Stakes for cut and fill limits shall establish the exterior limits of excavations and berms. The maximum staking interval shall be 25 feet. Stakes shall be prominently noted with description of point, vertical distance to design elevation, and offset distance as applicable.
- 2. Structures: Stake structure centerlines so that the orientation, position, limits, and foundation elevation(s) are positively identified. Mark stakes to reflect the design elevation and offset distance as applicable.
- 3. Swales and Channels: Stake swales and channels such that the layout remains undisturbed during construction.
- 4. Pipes and Culverts: Stake pipes and culverts on 25-ft maximum stationing. Place offset stakes beyond excavation limits and material stockpiles. Continuously check invert elevation during placement.

D. Final Surveys:

- 1. Final topography shall be staked at nominal 25-foot intervals. Additionally, the following points shall be staked and noted as applicable.
 - a. Grade breaks.
 - b. Mid-point of slopes less than 25 feet.
 - c. Points of horizontal curvature and tangency.
 - d. Limits of construction.
- 2. Pipes and Culverts: Survey alignment and elevations of the top of all pipes at each change in grade and every 25 feet between change in grades.

3.03 SURVEYS FOR MEASUREMENT

- A. Perform surveys to evaluate quantities of work performed and the percentage of work completed as directed by the Owner.
- B. Survey results and calculations may be needed to certify quantities.

3.04 FINAL SURVEYS AND AS-BUILT DOCUMENTS

- A. Conformance surveys (to verify that the lines and grades are achieved after completion of construction) and final record as-built surveys shall include the following:

1. For berms, drainage swales, and other earthwork:
 - a. original grade surface;
 - b. compacted surface of cut slopes, if applicable;
 - c. top of general fill; and
 - d. finished grade surface.
 2. For the cap liner system:
 - a. prepared subgrade (top of waste material);
 - b. top of compacted leveling layer;
 - c. layout of geomembrane panels including location of all destructive samples and repairs; and
 - d. outer limit and top of sandy drainage layer / erosion protection stone layer.
- B. Final record as-built surveys, signed and stamped, by a State of New Jersey Licensed/Registered Land Surveyor or Professional Engineer shall be submitted within 30 days of completion of the liner subbase (top of base grade on which geosynthetics will be installed) and completion of the liner protective cover.
- C. Perform conformance surveys and final record as-built surveys soon after completion of a given installation to verify compliance with the Construction Drawings, facilitate progress, and avoid delaying commencement of the next installation. Provide the following minimum spacing and locations for survey points:
1. surfaces with gradients less than 10 percent, survey on a square grid spaced no wider than 25 feet;
 2. on slopes greater than 10 percent, a square grid spaced no wider than 25 feet shall be used, but in all cases, a line at the crest, midpoint, and toe of the slope shall be surveyed;
 3. a line of survey points spaced no more than 25 feet apart shall be measured along any slope break (this will include the inside edge and outside edge of any bench on a slope); and
 4. a line of survey points spaced not more than 25 feet apart and at each end shall be taken at the top of any pipes, culverts, discharge structures, or other appurtenances.

[END OF SECTION]

SECTION 02200

EARTHWORK

PART 1 GENERAL

1.01 SCOPE

- A. This section includes the requirements for the fill soil used for the soil cover layer and the subbase/leveling layer.

1.02 REFERENCES

- A. Latest version of American Society of Testing and Materials (ASTM) standards and other standards noted in this specification.

1.03 SUBMITTALS

- A. Fifteen calendar days prior to start of earthwork, submit the following to the Engineer for review:
 - 1. construction methods for each construction activity;
 - 2. plan for survey work related to the earthwork;
 - 3. schedule for earthwork activities; and
 - 4. dust control measures.
- B. If fill is obtained from an off-site source, submit to the Engineer test results indicating that it is certified clean fill that meets the material requirements of this Section prior to bringing the materials to the site.
- C. Contractor shall perform construction quality control (CQC) testing on fill brought to the site in accordance with the requirements in this Section and submit the results to the Engineer for approval prior to using the fill for construction.
- D. Prior to placing a subsequent lift during construction, submit compaction test results to the CQA Consultant for approval.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. The earthwork will be monitored and tested by the CQA Consultant as required in the CQA Plan.

- B. The CQA Consultant will perform soil performance testing on the fill lifts to evaluate compliance with this Section. The CQA Consultant will indicate any portion of the earthwork that does not meet the requirements of this Section and will delineate the extent of the non-conforming area.
- C. The Contractor shall correct all deficiencies and non-conformances identified by the CQA Consultant at no additional cost to the Owner.
- D. The Contractor shall be aware of the activities required of the CQA Consultant by the CQA Plan and shall account for these activities in the construction schedule.

1.05 EXISTING CONDITIONS

- A. Existing site surface and subsurface conditions based on available site data are indicated on the Construction Drawings.
- B. Contractor shall verify the existing conditions and inform the Engineer of any major discrepancies/deviations from the conditions indicated.

PART 2 PRODUCTS

2.01 MATERIALS

All fill obtained from an offsite source shall be certified clean fill in accordance with the NJDEP requirements. Fill material shall be free of debris, foreign objects, large objects, organics, and other deleterious materials.

- A. Subbase fill: material used as liner subbase (6-inch thick layer immediately under the top liner system) shall be free of sharp materials or any materials larger than 0.5 inches and meet the following requirements:
 - a. have less than 10% fines; and
 - b. consist of course soils that classify as SW or SP in accordance with the Unified Soil Classification System (per ASTM D 2487). Soils having other classifications may be acceptable as general fill, if approved by the Engineer.
- B. Soil Cover fill: material used for soil cover (18-inch thick layer immediately on top of the top liner system) shall be free of sharp materials or any materials larger than 0.5 inches and meet the following requirements:
 - a. internal friction angle of 25 degrees (per ASTM D 3080/3080M);
 - b. maximum permeability of 1×10^{-3} cm/sec (per ASTM D 2434); and
 - c. material shall consist of sandy soils that classify as SW, SP, SW-SM, SW-SC, SP-SM, SP-SC, SM, or SC in accordance with the Unified Soil Classification

System (per ASTM D 2487). Soils having other classifications may be acceptable if approved by the Engineer.

2.02 CONSTRUCTION QUALITY CONTROL

- A. Contractor shall perform construction quality control (CQC) testing on materials brought to the site and provide the results to the CQA Consultant. CQC testing shall be performed on general fill to evaluate suitability of the materials that will be used in construction and to ensure that the earthwork meets the requirements of this Section.
- B. CQC testing performed on fill to evaluate suitability of the materials shall include particle size analysis (ASTM D 6913) and soil classification (ASTM D 2487). These tests shall be performed at a frequency of 1 test per 1,500 cubic yards of in-place compacted fill.
- C. CQC testing performed on soil cover fill to evaluate suitability of the materials shall include permeability of granular soils (ASTM D 2434) and direct shear of soils under consolidated drained conditions (ASTM D 3080/3080M). These tests shall be performed at a frequency of 1 test per 1,500 cubic yards of in-place compacted fill.
- D. CQC testing performed to ensure that the earthwork meets the requirements of this Section shall include Standard Proctor (ASTM D 698), in-situ moisture content (ASTM D 6938 or D 2216), in-situ density (ASTM D 6938 or D 1556 or D 2937) tests and interface friction angle (ASTM D 5321 and/or ASTM D 6243).
- E. Standard Proctor (ASTM D 698) tests shall be performed at a frequency of 1 test per 3,000 cubic yards of in-place compacted fill. If different soil types are used as general fill, standard Proctor tests shall be performed on each soil type to evaluate percent compaction in the field.
- F. In-situ moisture content (ASTM D 6938 or D 2216) and in-situ density (ASTM D 6938 or D 1556 or D 2937) tests shall be performed at a frequency of 10 tests per lift per acre or 2 tests per lift per 100 lineal feet.
- G. Interface Friction Angle Testing (ASTM D 5321 and/or ASTM D 6243) shall conform to Specification 02790.

2.03 EQUIPMENT

- A. Furnish equipment as needed, to perform the earthwork related to construction activities.

- B. Furnish appropriate compaction equipment needed to achieve the required compaction criteria for leveling layer.
- C. Furnish hand compaction equipment, for compaction in areas inaccessible to large compaction equipment.
- D. Furnish water trucks or other equipment designed to apply water uniformly and in controlled quantities for in-place moisture adjustment, to prevent drying of soil surfaces, and/or for dust control.

PART 3 EXECUTION

3.01 GENERAL

- A. All general fill material to be compacted shall be at a moisture content that will readily facilitate effective compaction.
- B. General fill material placed wet that exhibits pumping shall not be accepted regardless of the in-place density or percent compaction. Wet materials shall typically not be used. Wet materials, if used, shall be allowed to dry in place, if feasible, or removed and replaced with suitable materials as directed by the CQA Consultant.
- C. Once the leveling layer is installed it is the contractor's responsibility to keep it in good condition until the geomembrane installer has completed the construction of the liner system.

3.02 EXCAVATION

- A. Excavate indicated areas to the subgrade elevations and limits indicated on the Construction Drawings.

3.03 STOCKPILING

- A. Construct stockpiles no steeper than 3H:1V (3 horizontal to 1 vertical), grade to drain, seal by tracking perpendicular to the slope contours with a dozer, and dress daily during periods when fill is taken from the stockpile.
- B. Silt fence or berms shall be constructed at the base of stockpiles that will not be immediately used.
- C. Restore all areas used for stockpiling when stockpiles are removed as directed by the Owner.

3.04 SUBGRADE PREPARATION

- A. Subgrade material shall consist of waste material relatively free of debris, foreign objects, large objects, organics and other deleterious materials.

3.05 EXCAVATION DEWATERING

- A. Groundwater is at or near the existing ground surface. Anticipate seepage of groundwater as well as accumulation of surface water runoff in excavations. As a minimum, Contractor shall be prepared to lower the groundwater in localized areas as needed.
- B. Contractor shall expect that work areas may be inundated with water and shall be prepared to dewater, as required, to perform the work. Contractor shall prevent/minimize surface water run-on from adjacent areas from entering the work areas and/or the excavations.
- C. All fill operations shall be performed in the dry. Contractor shall be prepared to pump water to manage groundwater and/or surface water that may accumulate in excavations and/or the work areas.
- D. Water generated as part of excavation and/or work area dewatering activities shall be managed and pre-treated (if needed or required by Chevron Construction Manager) using a pre-treatment system (oil-water separator, holding tank, and/or filters). After pre-treatment and testing by Contractor, water generated as part of dewatering activities will be pumped to the on-site ETP.

3.06 FILL

- A. Contractor shall test the general fill in accordance with the requirements of this Section. Contractor shall only use fill that meets the requirements of this Section unless otherwise approved by the Engineer.
- B. Place fill to the limits and grades shown on the Construction Drawings.
- C. Place fill material on surfaces that are free of debris, vegetation, or other deleterious material.
- D. Place fill material in loose lifts with a thickness of 12 inches \pm 1 inch. In areas where compaction is to be performed using hand operated equipment, place the fill material in loose lifts with a thickness of 6 inches \pm 1 inch.

- E. After completion of a lift, Contractor shall perform in-situ moisture and density testing in accordance with the requirements of this Section. Contractor shall place a succeeding lift only after approval of the completed lift by the CQA Consultant.
- F. Prior to placing a succeeding lift of material over a previously compacted lift, thoroughly scarify the previous lift to a depth of 2 inches by discing, raking, or tracking with a dozer. Moisture condition the preceding lift if not within the acceptable moisture range.
- G. The trafficking of scarified surfaces by trucks or equipment other than the compaction equipment is not permitted.
- H. Except as specified in this Section, compact general fill in each lift to at least 90 percent of its standard Proctor maximum dry density (ASTM D 698). Compact general fill at moisture content as required to attain the specified density or as approved by the Engineer.
- I. Do not place fill during periods of precipitation. Placement may occur during periods of misting or drizzle, but only if authorized by the Chevron Construction Manager.
- J. Dust shall be controlled by the application of water to the general fill surfaces.
- K. Contractor shall coordinate the final surface of the liner subbase in the cell with the geosynthetics installer. Contractor is responsible for maintenance of the subbase until its acceptance by the geosynthetics installer.

3.07 SURVEY CONTROL

- A. Survey limits and elevations of excavations, subgrade, and top of general fill in accordance with Section 02100.

3.08 TOLERANCES

- A. Perform the earthwork construction related to the berms, base grades, sumps and perimeter swale to within ± 0.1 feet of the elevations and within 10 percent of the slopes indicated on the Construction Drawings.
- B. Positively draining slopes shall be maintained during all construction.

[END OF SECTION]

SECTION 02215

TRENCHING AND BACKFILLING

PART 1 GENERAL

1.01 SCOPE

- A. This section describes the requirements to perform work associated with trenching, backfilling, placing, and compacting materials. As a minimum, trenching and backfilling will be required for installation of the geomembrane.

1.02 REFERENCES

- A. Latest version of American Society of Testing and Materials (ASTM) standards and other standards noted in this specification.
- B. Latest version of Occupational Safety and Health Administration (OSHA) Construction Standards.

1.03 SUBMITTALS

- A. If the embedment fill material is different than the fill, submit the source of the embedment fill, a representative sample, and results of tests conducted on the embedment fill samples in accordance with ASTM C 136 and ASTM D 2487 to the Engineer prior to bringing material to site.
- B. After completion of construction, Contractor shall submit conformance survey results in accordance with the requirements of this Section.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. The trenching and backfilling will be monitored by the CQA Consultant as required in the CQA Plan.
- B. The Contractor shall be aware of the activities required of the CQA Consultant in the CQA Plan and shall account for these activities in the construction schedule.
- C. The Contractor shall correct all deficiencies and non-conformances identified by the CQA Consultant at no additional cost to Chevron.

1.05 EXISTING CONDITIONS

- A. In advance of trenching in an area, verify the accuracy of existing conditions indicated on the Construction Drawings. Immediately notify the Engineer of deviations from the existing conditions indicated on the Construction Drawings.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Embedment and backfill materials for the geomembrane anchor trench shall meet the material requirements for fill as specified in Section 02200.

2.02 EQUIPMENT

- A. Provide all equipment necessary to perform the work described in this Section.

PART 3 EXECUTION

3.01 GENERAL

- A. In areas of trenching and backfilling, maintain and protect any existing underground utilities, above ground utilities, and/or other structures. Any damage to the existing utilities and/or structures shall be restored as directed by Chevron Construction Manager at no additional cost to Chevron.

3.02 TRENCHING

- A. Use sheeting and bracing where and whenever necessary to maintain the safety and stability of all slopes, trenches, and adjacent structures, if needed. Satisfy all applicable Chevron and the Occupational Safety and Health Administration (OSHA) requirements for slope and trench excavation.
- B. Trench soils to perform the required work to depths and minimum dimensions indicated on the Construction Drawings. Fill material shall be placed and compacted with a hand tamper so as not to displace and/or damage the pipes, geosynthetics, or the structures.
- C. Protect and maintain the trench bottom. Remove rock fragments or raveled materials that may collect on the trench bottom. Excavate any soft subgrade soils encountered at

the trench bottom. Use specified embedment materials to backfill over-excavation. Backfill and compact to trench bottom elevation with specified embedment materials.

- D. Dewater trenches and excavations as needed. Perform dewatering in accordance with Section 02200. Water generated as part of trench dewatering activities shall be managed and pre-treated (if needed or required by Chevron Construction Manager) using a pre-treatment system (oil-water separator, holding tank, and/or filters). After pre-treatment and testing by Contractor, water generated as part of dewatering activities will be pumped to the on-site ETP.
- E. Stockpile or dispose excavated materials impacted with LNAPL and/or excess materials from trench excavation as directed by Chevron Construction Manager.

3.03 BACKFILLING

- A. General:
 - 1. Do not backfill with saturated material;
 - 2. Do not backfill over wet or soft subgrade;
 - 3. Do not displace or damage the installed geomembrane while backfilling; and
 - 4. Do not use heavy compaction equipment which exerts greater than 5 pounds per square inch ground pressure over geomembrane that is covered by less than 12 inches of backfill material.
- B. Placement of backfill material:
 - 1. Place the first lift of backfill material in a 12-inch loose lift. Place subsequent lifts of trench backfill material in 8-inch \pm 1-inch loose lifts; and
 - 2. Compact each lift to 95 percent of the maximum standard Proctor dry unit weight at a moisture content generally within \pm 5 percent of the optimum moisture content as determined by ASTM D 698 or as directed by the Engineer.
- C. Placement of embedment fill:
 - 1. Place embedment fill in 6-inch \pm 1-inch thick loose lifts to the elevation of the bottom of the pipe;
 - 2. Compact embedment fill with a minimum of 4 passes of a vibratory plate compactor prior to placing pipe;
 - 3. Place pipe on top of the compacted embedment fill;
 - 4. For pipes 12 inches in diameter or less, place additional pipe embedment fill on the sides and hand tamp the fill around the sides as needed to ensure intimate contact between the pipe and the embedment fill below the spring line. Continue placing embedment fill until it is even with the top of the pipe. Compact the embedment fill

with a minimum of 4 passes of a vibratory plate compactor. Do not compact on top of the pipe unless a minimum of 12 inches of trench backfill separates the compactor from the top of the pipe; and

5. For pipes greater than 12 inches in diameter, place embedment fill in 8-inch \pm 1-inch thick loose lifts to the top of the pipe. Compact each lift with a minimum of 4 passes of a vibratory plate compactor.

3.04 SURVEY CONTROL

- A. Survey the limits and bottom elevations of the trenches in accordance with Section 02100.
- B. Survey the limits and invert elevations of all pipes and structures in accordance with Section 02100.
- C. Survey the alignment and elevations of the top of all pipes at each change in grade and every 25 feet between changes in grades in accordance with Section 02100.

3.05 TOLERANCES

- A. Install pipes to within \pm 0.1 feet of the elevations and within 10 percent of the slopes indicated on the Construction Drawings.
- B. Excavate anchor trenches within 0 to +0.2 feet of the depth indicated on the Construction Drawings.

[END OF SECTION]

SECTION 02235

GRAVEL

PART 1 GENERAL

1.01 SCOPE

- A. This section includes the requirements for gravel that will be placed as stone cover on the CAMU cap.

1.02 REFERENCES

- A. Latest version of American Society of Testing and Materials (ASTM) standards and other standards noted in this specification.

1.03 SUBMITTALS

- A. For each source of gravel material, the Contractor shall submit the following to the Engineer for review prior to bringing the material onsite:
 - 1. Source of the material;
 - 2. A test result conducted on each material such that the material is fully represented in accordance with ASTM C 136, ASTM D 3042, and ASTM D 2434; and
 - 3. A representative sample of the material.
- B. Contractor shall perform construction quality control (CQC) testing on materials brought to the site in accordance with the requirements of this Section and submit the results to the CQA Consultant for approval prior to using the materials for construction.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. The installation of the gravel material will be monitored by the CQA Consultant as required in the CQA Plan.
- B. The CQA Consultant will perform material conformance testing and installation quality control testing on the granular drainage materials as required in the CQA Plan.
- C. The Contractor shall be aware of the activities required of the CQA Consultant by the CQA Plan and shall account for these activities in the construction schedule.
- D. The Contractor shall correct all deficiencies and non-conformances identified by the CQA Consultant at no additional cost to the Owner.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Furnish gravel material consisting of homogeneous crushed or natural stones that are free of materials that, due to their nature or size are deleterious to the intended use as determined by the Engineer.
- B. Gravel will be used on CAMU cap to prevent erosion as indicated in the Construction Drawings. This stone shall be clean 2 to 3-inch stone.

2.02 CONSTRUCTION QUALITY CONTROL

- A. Contractor shall perform construction quality control (CQC) testing on materials brought to the site and provide the results to the CQA Consultant. CQC testing shall be performed on granular drainage material to evaluate suitability of the materials that will be used in construction.

2.03 EQUIPMENT

- A. Furnish, operate, and maintain equipment necessary to transport, place, and spread the granular drainage materials without damage to the geosynthetics.

PART 3 EXECUTION

3.01 MATERIAL PLACEMENT

- A. Do not commence placement of the gravel material until the CQA Consultant has completed conformance evaluation of the material and evaluation of previous work, including evaluation of the Contractor's survey results for previous work.
- B. Place the granular drainage material to the minimum thicknesses and limits indicated on the Construction Drawings.
- C. The stone shall be placed on top of nonwoven needle punched geotextile fabric. The geotextile fabric shall be GSE NW8 or equivalent having a minimum mass per unit area of 8 ounce per square yard.

3.02 SURVEY CONTROL

- A. Survey the limits and elevations of the top of the granular drainage material in accordance with Section 02100.

3.03 TOLERANCES

- A. Place the granular drainage materials to within +0.2 feet thicknesses indicated on the Construction Drawings.

[END OF SECTION]

SECTION 02621

GEOCOMPOSITES

PART 1 GENERAL

1.01 SCOPE

This specification covers the technical requirements for the manufacturing and installation of the geocomposite used in the drainage layer of the cap cover system. All materials meet or exceed the requirements of this specification, and all work will be performed in accordance with the procedures provided in these project specifications.

1.02 REFERENCES

- A. Latest version of American Society of Testing and Materials (ASTM) standards and other standards noted in this specification

1.03 QUALIFICATIONS

- A. Geocomposite Drainage Manufacturer:
 - 1. The Geocomposite manufacturer shall be responsible to produce geocomposite rolls consisting of a geonet core with heat-laminated geotextiles and shall have sufficient production capacity and qualified personnel to meet the demands (e.g., quantity production and quality control) of this project.
 - 2. The Geocomposite manufacturer shall have successfully manufactured a minimum of 10,000,000 square feet of similar geocomposite drainage material for use in at least ten similar projects in the past five years.
- B. Geosynthetic Installer:
 - 1. The Installer shall be responsible for field handling, storing, deploying, temporarily restraining (against wind), and other site aspects associated with the geocomposite and shall provide qualified installation personnel, as outlined in this Section. The Geosynthetic Installer may also be responsible for transportation of these materials to the site, and for anchoring systems.
 - 2. As a firm, the Geosynthetic Installer shall have successfully installed a minimum of 5,000,000 square feet of similar geocomposites for at least ten projects in the past five years.
 - 3. The superintendent assigned to this project shall have supervised the installation of a minimum of 2,000,000 square feet of similar geocomposites on at least ten similar projects.

1.04 SUBMITTALS

- A. Submit the following information to the Engineer for review not less than 30 calendar days prior to geocomposite use.
 - 1. Geocomposite manufacturer capabilities including manufacturing quality control procedures.
 - 2. Certification that the geocomposite manufacturer meets the noted qualifications.
 - 3. Origin (resin supplier's name, resin production plant) and identification (brand name, number) of the polyethylene resin used.
 - 4. Certification of minimum/maximum average roll values (95 percent lower confidence limit) for physical, mechanical, and environmental properties and the corresponding test procedures for the geocomposite properties listed in Table 02770-1. Submit values that are specific to the resin used in manufacturing the geocomposite.
 - 5. Manufacturer warranty as specified in this Section.
- B. Submit to the Engineer for review not less than 30 calendar days prior to geocomposite use the following documentation on the resin used to manufacture the composites:
 - 1. Copies of quality control certificates issued by the resin supplier including the production dates and origin of the resin used to manufacture the geocomposite for this project.
 - 2. Results of tests conducted by the manufacturer to verify the quality of the resin used to manufacture the geocomposite rolls assigned to the project.
- C. Submit to the Engineer for review the following documentation on geocomposite roll production at least 14 calendar days prior to transporting any geocomposite to the facility.
 - 1. Manufacturing certificates signed by the manufacturer quality control manager.
 - 2. Certificate shall include:
 - a. roll numbers and identification;
 - b. sampling procedures; and
 - c. results of manufacturer quality control tests including the test methods used (Manufacturer quality control tests to be performed are given in Part 2 of this Section).
- D. Submit to the Engineer for review the following information from the installer at least 14 calendar days prior to mobilization of the installer to the site.
 - 1. Layout drawings showing the installation layout identifying geocomposite panel configurations, dimensions, details, locations of overlaps/seams as well as any variance or additional details which deviate from the Construction Drawings. The layout drawings shall be adequate for use as a construction plan and shall include dimensions, details, etc. The layout drawings, as modified and/or approved by the Engineer, shall be used during construction.
 - 2. Installation schedule.
 - 3. Copy of installer's letter of approval or license by the manufacturer.
 - 4. Installation capabilities, including:
 - a. information on equipment proposed for this project;

- b. average daily production anticipated for this project; and
 - c. quality control procedures to include quality control organization.
 - 5. A list of 10 completed facilities for which the installer has installed a minimum of 50,000 square feet of geocomposites. The following information shall be provided for each facility:
 - a. the name and purpose of the facility, its location, and dates of installation;
 - b. the names of the owner, project manager, and geocomposite manufacturer;
 - c. name and qualifications of the supervisor of the installation crew;
 - d. surface area of installed geocomposite; and
 - e. duration of installation.
 - 6. Resumes of the installer superintendent and quality control chief to be assigned to this project, including dates and duration of employment.
 - 7. Evidence that the installation crew has the following experience.
 - a. The superintendent shall have supervised the installation of a minimum of 2,000,000 square feet of geocomposites.
- E. After completion of the geocomposite installation, submit to the Engineer the executed installation warranty as specified in this Section.

1.05 CONSTRUCTION QUALITY ASSURANCE

- A. The construction of the geocomposite component of the liner system will be monitored by the CQA Consultant as required in the CQA Plan.
- B. The CQA Consultant will perform material conformance testing of geocomposite materials and installation quality assurance testing of the geocomposite liner seams.
- C. The Contractor shall be aware of the activities required of the CQA Consultant by the CQA Plan and shall account for these activities in the construction schedule.
- D. The Contractor shall correct all deficiencies and nonconformances identified by the CQA Consultant at no additional cost to the Owner.

PART 2 PRODUCTS

2.01 RESIN

- A. Provide geocomposite manufactured from new, first-quality polyethylene resin. Do not add reclaimed polymer to the resin.
- B. Natural resin (without carbon black) shall meet the following additional minimum requirements:
 - 1. Density (g/cm³) (min.): 0.94 (ASTM D 1505)
 - 2. Melt Index (g/10 min) (max.): 1.0 g/10 min (ASTM D 1238)

2.02 GEOCOMPOSITE PROPERTIES

- A. A geocomposite shall be manufactured by extruding two crossing strands to form a bi-planar drainage net structure with a non-woven geotextile bonded to one or both sides.
- B. The geocomposite specified shall have properties that meet or exceed the values listed in Table 02621-1

2.03 MANUFACTURING QUALITY CONTROL

- A. Resin:
 - 1. Sample and test resin at a minimum frequency of one test per rail car to demonstrate that the resin complies with the requirements of this Section. Perform tests on resin after the addition of additives to the virgin resin. Certify in writing that the resin meets the requirements of this Section.
 - 2. Do not use any noncomplying resin.
- B. Rolls:
 - 1. The geocomposite shall be manufactured in accordance with the Manufacturer's Quality Control Plan submitted to and approved by the ENGINEER.
 - 2. The geocomposite shall be tested according to the test methods and frequencies listed on Table 02621-2 which has been prepared based on product data sheets.
 - 3. If a geocomposite sample fails to meet the quality control requirements of this Section, sample and test rolls manufactured in the same resin batch or at the same time as the failing roll. Continue to sample and test the rolls until the extent of the failing rolls are bracketed by passing rolls. Do not supply any failing rolls.

2.04 LABELING

- A. Each roll delivered to the site shall be wrapped and labeled by the manufacturer. The label will identify:
 - 1. Name of Manufacturer;
 - 2. Product identification;
 - 3. Length of roll
 - 4. width of the roll;
 - 5. Lot number; and
 - 6. Roll number.
- B. Geocomposite rolls not labeled in accordance with this Section or on which labels are illegible upon arrival at the site will be rejected and replaced at no additional expense to the Owner.

2.05 TRANSPORTATION, HANDLING AND STORAGE

- A. Rolls will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.

- B. Deliver geocomposite to the facility at least 14 calendar days prior to the planned deployment date to allow the CQA Consultant adequate time to perform conformance testing on the geocomposite samples as described in the CQA Plan.
- C. Provide proper handling and storage of the geocomposite at the facility. Protect the geocomposite from excessive heat or cold, dirt, puncture, cutting, or other damaging or deleterious conditions and shall have the following characteristics.
 - 1. level (no wooden pallets)
 - 2. smooth
 - 3. dry
 - 4. protected from theft and vandalism
 - 5. adjacent to the area being lined

2.06 WARRANTY

- A. Material shall be warranted, on a pro-rata basis against defects for a period of 1-year from the date of the geocomposite installation.
- B. Installation shall be warranted against defects in workmanship for a period of 1-year from the date of geocomposite completion.

PART 3 EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any of the work described in this Section, the Contractor shall become thoroughly familiar with all portions of the work falling within this Section.
- B. Inspection:
 - 1. Prior to implementing any of the work in this section, the Contractor shall carefully inspect the installed work of all other sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.
 - 2. If the Contractor has any concerns regarding the installed work of other sections, the Contractor shall immediately notify the Engineer in writing. Failure to inform the Engineer in writing or continuance of installation of the geocomposite will be construed as the Contractor's acceptance of the related work of all other sections.

3.02 SUBGRADE SURFACE PREPARATION

- A. The Contractor shall provide certification in writing that the surface on which the geocomposite will be installed is acceptable. Where other geosynthetics (geomembrane) is installed on the subgrade prior to the geocomposite, the Contractor shall inspect the subgrade prior to that geosynthetics (geomembrane) installation. This certification of acceptance shall be given to the CQA Consultant prior to commencement of geomembrane installation in the area under consideration.

- B. Special care shall be taken to maintain the prepared surface.
- C. No geocomposite shall be placed onto areas of standing water.
- D. Any damage to the geomembrane or prepared subgrade caused by installation activities shall be repaired at the Contractor's expense.

3.03 GEOCOMPOSITE DEPLOYMENT

A. General:

- 1. The Contractor shall produce layout drawings prior to geocomposite deployment. These drawings shall indicate the geocomposite configuration, dimensions, details, locations of seams, etc. The layout drawings must be approved by the Engineer prior to the installation of any geocomposites. The layout drawings, as modified and/or approved by the Engineer, shall become part of these Specifications.
- 2. Do not deploy geocomposite until the layout drawings are approved by the Engineer.
- 3. Do not deploy a geocomposite panel in an area until the CQA Consultant has been provided with a certificate of subgrade acceptance for that area.
- 4. Do not deploy geocomposites until CQA Consultant completes conformance evaluation of the geocomposite and performance evaluation of previous work, including evaluation of Contractor's survey results for previous work.
- 5. Deploy each geocomposite panel in accordance with the approved layout drawings.

B. Field Panel Identification:

- 1. A geocomposite field panel is a roll or a portion of roll cut in the field.
- 2. Give each field panel an identification code (number or letter-number). This identification code shall be agreed upon by the CQA Consultant and the Installer.

3.04 GEOCOMPOSITE PLACEMENT

- A. The geocomposite roll should be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by the engineer.
- B. If the project contains long, steep slopes, special care should be taken so that only full-length rolls are used at the top of the slope.
- C. In the presence of wind, all geocomposites shall be weighted down with sandbags or the equivalent. Such sandbags shall be used during placement and remain until replaced with cover material.
- D. If the project includes an anchor trench at the top of the slopes, the geocomposite shall be properly anchored to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the geocomposite.
- E. In applying fill material, no equipment can drive directly across the geocomposite. The specified fill material shall be placed and spread utilizing vehicles with a low ground pressure.
- F. The cover soil shall be placed in the geocomposite in a manner that prevents damage to the geocomposite. Placement of the cover soil shall proceed immediately following the placement and inspection of the geocomposite.

3.05 SEAMS AND OVERLAPS

- A. Each component of the geocomposite will be secured or seamed to the like component at overlaps.
- B. Geonet Components
 - 1. Adjacent edges of the geonet along the length of the geocomposite roll shall be placed with the edges of each geonet butted against each other.
 - 2. The overlaps shall be joined by tying the geonet structure with cable ties. These ties shall be spaced every 5 feet along the roll length.
 - 3. Adjoining geocomposite rolls (end to end) across the roll width should be shingled down in the direction of the slope, with the geonet portion of the top overlapping the geonet portion of the bottom geocomposite a minimum of 12 inches across the roll width.
 - 4. The geonet portion should be tied every 6 inches in the anchor trench or as specified by the engineer.

3.06 DEFECTS AND REPAIRS

- A. Prior to covering the deployed geocomposite, each roll shall be inspected for damage resulting from construction.
- B. Any rips, tears or damaged areas on the deployed geocomposite shall be removed and patched. The patch shall be secured to the original geonet by tying every 6 inches with the approved tying devices. If the area to be repaired is more than 50 percent of the width of the panel, the damaged area shall be cut out and the two portions of the geonet shall be cut out and the two portions of the geonet shall be joined in accordance with Subsection 3.05.

3.07 SURVEY CONTROL

- A. Survey the installed geocomposite liner in accordance with Section 02100.

3.08 GEOCOMPOSITE ACCEPTANCE

- A. The Contractor shall retain all ownership and responsibility for the geocomposite until accepted by the Owner.
- B. The geocomposite shall be accepted by the Owner when:
 - 1. Installation is finished;
 - 2. All documentation of installation is completed including the CQA Consultant's final report; and
 - 3. Verification of the adequacy of all field seams and repairs, including associated testing, is complete.

3.07 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all prior work and all materials and completed work of other sections.
- C. In the event of damage, the Contractor shall make all repairs and replacements necessary at no additional cost to Owner.

Table 02621-1

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM AVERAGE ROLL VALUE ^(a)		
Geocomposite			6 oz/yd ²	8 oz/yd ²	10 oz/yd ²
Product Code			F420600605	F420800805	F421001005
Transmissivity ^(b) , gal/min/ft (m ² /sec)	ASTM D 4716	1/540,000 ft ²	0.48 (1 x 10 ⁻⁴)	0.48 (1 x 10 ⁻⁴)	0.43 (9 x 10 ⁻⁵)
Ply Adhesion, lb/in (g/cm)	ASTM D 7005	1/50,000 ft ²	1.0 (178)	1.0 (178)	1.0 (178)
Roll Width ^(c) , ft (m)			14.5 (4.4)	14.5 (4.4)	14.5 (4.4)
Roll Length ^(c) , ft (m)			230 (70.1)	200 (60.9)	190 (58.0)
Roll Area, ft ² (m ²)			3,335 (310)	2,900 (269)	2,755 (256)
Geonet core^(d)					
Transmissivity ^(b) , gal/min/ft (m ² /sec)	ASTM D 4716		9.66 (2 x 10 ⁻³)	9.66 (2 x 10 ⁻³)	9.66 (2 x 10 ⁻³)
Thickness, mil (mm)	ASTM D 5199	1/50,000 ft ²	200 (5)	200 (5)	200 (5)
Density, g/cm ³	ASTM D 1505	1/50,000 ft ²	0.94	0.94	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5035	1/50,000 ft ²	45 (7.9)	45 (7.9)	45 (7.9)
Carbon Black Content, %	ASTM D 1603	1/50,000 ft ²	2.0	2.0	2.0
Geotextile (prior to lamination)^(d,e)					
Mass per Unit Area, oz/yd ² (g/m ²)	ASTM D 5261	1/90,000 ft ²	6 (200)	8 (270)	10 (335)
Grab Tensile, lb (N)	ASTM D 4632	1/90,000 ft ²	170 (755)	220 (975)	260 (1,155)
Puncture Strength, lb (N)	ASTM D 4833	1/90,000 ft ²	90 (395)	120 (525)	165 (725)
AOS, US sieve (mm)	ASTM D 4751	1/540,000 ft ²	70 (0.212)	80 (0.180)	100 (0.150)
Permittivity, (sec ⁻¹)	ASTM D 4491	1/540,000 ft ²	1.5	1.5	1.2
Flow Rate, gpm/ft ² (lpm/m ²)	ASTM D 4491	1/540,000 ft ²	110 (4,480)	110 (4,480)	85 (3,460)
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	once per formulation	70	70	70

NOTES:

- ^(a)These are MARV values that are based on the cumulative results of specimens tested and determined by GSE. AOS in mm is a maximum average roll value.
- ^(b)Gradient of 0.1, normal load of 10,000 psf, water at 70° F between steel plates for 15 minutes.
- ^(c)Roll widths and lengths have a tolerance of ±1%.
- ^(d)Component properties prior to lamination.
- ^(e)Refer to geotextile product data sheet for additional specifications.

Table 02621-2

Characteristics	Test Method	Units	FREQUENCY
			Bi-Planar
<i>Resin</i>			
Polymer Density	ASTM D 1505	g/cm ³	Once Per Lot
Melt Flow Index	ASTM D 1238	g/10 min	Once Per Lot
<i>Geonet Test</i>			
Carbon Black	ASTM D 1603	%	1/50,000 ft ²
Tensile Strength, MD	ASTM D 5035	lb/ ft	1/50,000 ft ²
Density	ASTM D 1505	g/cm ³	1/50,000 ft ²
<i>Geotextile Tests</i>			
Mass per Unit Area	ASTM D 5261	oz/yd ²	1/90,000 ft ²
Grab Tensile	ASTM D 4632	lb	1/90,000 ft ²
Puncture	ASTM D 4833	lb	1/90,000 ft ²
AOS, US Sieve	ASTM D 4751	mm	1/540,000 ft ²
Water Flow Rate	ASTM D 4491	gpm/ft ²	1/540,000 ft ²
UV Resistance	ASTM D 4355 (after 500 hours)	% retained	Once per resin formulation
<i>Geocomposite Tests</i>			
Ply Adhesion	ASTM D7005	lb/in	1/50,000 ft ²
Transmissivity	ASTM D 4716	m ² /sec	1/540,000 ft ²

[END OF SECTION]

SECTION 02770

GEOMEMBRANE

PART 1 GENERAL

1.01 SCOPE

- A. This section includes product and installation requirements for geomembrane.

1.02 REFERENCES

- A. Latest version of American Society of Testing and Materials (ASTM) standards and other standards noted in this specification

1.03 QUALIFICATIONS

- A. Geomembrane Manufacturer:

1. The Geomembrane manufacturer shall be responsible to produce geomembrane rolls from resin and shall have sufficient production capacity and qualified personnel to meet the demands (e.g., quantity production and quality control) of this project.
2. The Geomembrane manufacturer shall have successfully manufactured a minimum of 10,000,000 square feet of HDPE and PE geomembrane for use in at least ten similar projects in the past five years.

- B. Geosynthetic Installer:

1. The Installer shall be responsible for field handling, storing, deploying, seaming, temporarily restraining (against wind), and other site aspects of the geomembrane and other components of the liner system, and shall provide qualified installation personnel, as outlined in this Section. The Geosynthetic Installer may also be responsible for transportation of these materials to the site, and for anchoring systems.
2. As a firm, the Geosynthetic Installer shall have successfully installed a minimum of 5,000,000 square feet of HDPE and PE geomembrane for at least ten projects in the past five years.
3. The superintendent assigned to this project shall have supervised the installation of a minimum of 2,000,000 square feet of HDPE and PE geomembrane on at least ten similar projects.
4. All personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests.
 - a. At least one seamer shall have experience seaming a minimum of 1,000,000 square feet of polyethylene geomembrane using the same type of seaming apparatus that will be used at this facility. Seamers with such

experience will be designated "master seamers" and shall provide direct supervision over less experienced seamers.

- b. All seaming personnel shall have seamed at least 100,000 square ft of polyethylene geomembrane using the same type of seaming apparatus that will be used at this facility.

1.04 SUBMITTALS

- A. Submit the following information to the Engineer for review not less than 30 calendar days prior to geomembrane use.
 1. Geomembrane manufacturer capabilities including manufacturing quality control procedures.
 2. Certification that the geomembrane manufacturer meets the noted qualifications.
 3. Origin (resin supplier's name, resin production plant) and identification (brand name, number) of the polyethylene resin used.
 4. Certification of minimum/maximum average roll values (95 percent lower confidence limit) for physical, mechanical, and environmental properties and the corresponding test procedures for the geomembrane properties listed in Table 02770-1. Submit values that are specific to the resin used in manufacturing the geomembrane.
 5. Certification that welding rod or granules are compatible with the specifications and the resin of the geomembrane furnished for this project
 6. Manufacturer warranty as specified in this Section.
- B. Submit to the Engineer for review not less than 30 calendar days prior to geomembrane use the following documentation on the resin used to manufacture the geomembranes:
 1. Copies of quality control certificates issued by the resin supplier including the production dates and origin of the resin used to manufacture the geomembrane for this project.
 2. Results of tests conducted by the manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project.
 3. Certification that no more than 10 percent reclaimed polymer is added to the resin during the manufacturing of the geomembrane that will be used for this project and that all reclaimed polymer (if added) is same as the parent material.
- C. Submit to the Engineer for review the following documentation on geomembrane roll production at least 14 calendar days prior to transporting any geomembrane to the facility.
 1. Manufacturing certificates signed by the manufacturer quality control manager.
 2. Certificate shall include:
 - a. roll numbers and identification;
 - b. sampling procedures; and
 - c. results of manufacturer quality control tests including the test methods used (Manufacturer quality control tests to be performed are given in Part 2 of this Section).

- D. Submit to the Engineer for review the following information from the installer at least 14 calendar days prior to mobilization of the installer to the site.
1. Layout drawings showing the installation layout identifying geomembrane panel configurations, dimensions, details, locations of seams, as well as any variance or additional details which deviate from the Construction Drawings. The layout drawings shall be adequate for use as a construction plan and shall include dimensions, details, etc. The layout drawings, as modified and/or approved by the Engineer, shall be used during construction.
 2. Installation schedule.
 3. Copy of installer's letter of approval or license by the manufacturer.
 4. Installation capabilities, including:
 - a. information on equipment proposed for this project;
 - b. average daily production anticipated for this project; and
 - c. quality control procedures to include quality control organization.
 5. A list of 10 completed facilities for which the installer has installed a minimum of 5,000,000 square feet of polyethylene geomembrane. The following information shall be provided for each facility:
 - a. the name and purpose of the facility, its location, and dates of installation;
 - b. the names of the owner, project manager, and geomembrane manufacturer;
 - c. name and qualifications of the supervisor of the installation crew;
 - d. thickness and surface area of installed geomembrane;
 - e. type of seaming and type of seaming apparatus used; and
 - f. duration of installation.
 6. Resumes of the installer superintendent and quality control chief to be assigned to this project, including dates and duration of employment.
 7. Resumes of all personnel who will perform seaming operations on this project, including dates and duration of employment.
 8. Evidence that the installation crew has the following experience.
 - a. The superintendent shall have supervised the installation of a minimum of 2,000,000 square feet of polyethylene geomembrane.
 - b. At least one seamer shall have experience seaming a minimum of 1,000,000 square feet of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Seamers with such experience will be designated "master seamers" and shall provide direct supervision over less experienced seamers.
 - c. All other seaming personnel shall have seamed at least 100,000 square feet of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Personnel who have seamed less than 100,000 square feet of seams shall be allowed to seam only under the direct supervision of the master seamer or Superintendent.
- E. Submit to the Engineer for review at least 14 days prior to geomembrane placement, a certificate of calibration less than 12 months old for the field tensiometer. Tensiometer shall be calibrated within one year of date of test. Calibration shall be traceable to national or industry recognized standards where possible.

- F. Submit subgrade acceptance certificates, signed by the Installer, for each area to be covered by the geosynthetics prior to that area being covered by the geosynthetics.
- G. After completion of the geomembrane installation, submit to the Engineer the executed installation warranty as specified in this Section.

1.05 CONSTRUCTION QUALITY ASSURANCE

- A. The construction of the geomembrane component of the liner system will be monitored by the CQA Consultant as required in the CQA Plan.
- B. The CQA Consultant will perform material conformance testing of geomembrane materials and installation quality assurance testing of the geomembrane liner seams. Contractor will be responsible for providing geomembrane and seam samples to the CQA Consultant to perform the required testing.
- C. The Contractor shall be aware of the activities required of the CQA Consultant by the CQA Plan and shall account for these activities in the construction schedule.
- D. The Contractor shall correct all deficiencies and nonconformances identified by the CQA Consultant at no additional cost to the Owner.

PART 2 PRODUCTS

2.01 RESIN

- A. Provide geomembrane manufactured from new, first-quality polyethylene resin. Do not add reclaimed polymer to the resin. The use of polymer recycled during the manufacturing process is permitted if performed with appropriate cleanliness and if the recycled polymer during the manufacturing process does not exceed 10 percent by weight of the total polymer weight.
- B. Use high density polyethylene (HDPE) resin for bottom liner system geomembranes having the following properties:
 - 1. Specific Gravity (min.): 0.932 (ASTM D 792 Method B, or ASTM D 1505)
 - 2. Melt Index (max.): 1.0 g/10 min (ASTM D 1238)

2.02 GEOMEMBRANE PROPERTIES

- A. Furnish 60-mil HDPE textured (two-sides) geomembranes having properties that comply with the required values shown in Table 02770-1. Either black or white surfaced geomembrane may be supplied.
- B. Furnish geomembranes that meet the interface shear strength requirements of Section 02790 as tested by an approved testing laboratory.
- C. In addition, furnish geomembrane that:

1. Contains a maximum of 1 percent by weight of additives, fillers, or extenders not including carbon black;
2. Does not have striations, pinholes, bubbles, blisters, nodules, undispersed raw materials, or any sign of contamination by foreign matter on the surface or in the interior;
3. Is free of holes, blisters, modules, undispersed raw materials, or any sign of contamination by foreign matter; and
4. Is manufactured in a single layer (thinner layers shall not be welded together to produce the final required thickness).

2.03 MANUFACTURING QUALITY CONTROL

A. Resin:

1. Sample and test resin at a minimum frequency of one test per rail car to demonstrate that the resin complies with the requirements of this Section. Perform tests on resin after the addition of additives to the virgin resin. Certify in writing that the resin meets the requirements of this Section.
2. Do not use any noncomplying resin.

B. Rolls:

1. Continuously monitor for geomembrane defects during manufacture. Geomembranes shall be subjected to continuous spark testing by the Manufacturer at the factory.
2. Do not supply geomembrane that exhibits any defects.
3. Regularly monitor for geomembrane thickness during manufacturing.
4. Do not supply geomembrane that fails to meet the specified thickness.
5. Sample and test the geomembrane, to demonstrate that its properties conform to the values specified in Table 02770-1. Perform the manufacture quality control tests at the following minimum frequencies with minimum of one test per lot:

<u>Test</u>	<u>Frequency</u>
Thickness	Every Roll
Asperity height	Every 2 nd Roll
Density	200,000 lb
Yield strength	20,000 lb
Yield elongation	20,000 lb
Break strength	20,000 lb
Break elongation	20,000 lb
Carbon black	20,000 lb
Carbon black dispersion	45,000 lb
Tear resistance	45,000 lb
Puncture resistance	45,000 lb
Oxidative induction time (OIT)	200,000 lb
Stress crack resistance	400,000 lb

Notes: (i) Typical 60-mil roll (460-ft long and 23-ft wide) weighs approximately 3,100 lb assuming a specific gravity of 0.94. (ii) A resin lot is approximately 200,000 lb.

6. For OIT, provide results for tests conducted on rolls supplied for the project or rolls manufactured from the same resin lot as the rolls supplied for the project. For stress crack resistance (SP-NCTL), preferably select rolls from a resin lot on which the SP-NCTL test has been performed. Otherwise, provide a written certification that the geomembrane meets the stress crack resistance requirements specified in GRI-GM13.
7. If a geomembrane sample fails to meet the quality control requirements of this Section, sample and test rolls manufactured, in the same resin batch, or at the same time, as the failing roll. Continue to sample and test the rolls until the extent of the failing rolls are bracketed by passing rolls. Do not supply any failing rolls.
8. Provide a written certification that the geomembrane meets the material requirements specified in GRI-GM13 for the following properties using the indicated test procedures. Provide written certification that these tests have been performed on geomembrane rolls having the same formulation as the geomembrane rolls that will be delivered for the project.

Test

Procedure

Oven aging
UV resistance

ASTM D 5721
ASTM D 7238

2.04 LABELING

- A. Label the geomembrane rolls with the following information.
 1. Thickness of the material;
 2. Length and width of the roll;
 3. Name of Manufacturer;
 4. Product identification;
 5. Lot number; and
 6. Roll number.
- B. Geomembrane rolls not labeled in accordance with this Section or on which labels are illegible upon arrival at the site will be rejected and replaced at no additional expense to the Owner.

2.05 TRANSPORTATION, HANDLING AND STORAGE

- A. Deliver geomembranes to the facility at least 14 calendar days prior to the planned deployment date to allow the CQA Consultant adequate time to perform conformance testing on the geomembrane samples as described in the CQA Plan.
- B. Provide proper handling and storage of the geomembrane at the facility. Protect the geomembrane from excessive heat or cold, dirt, puncture, cutting, or other damaging or

deleterious conditions. Provide any additional storage procedures required by the Manufacturer.

- C. Store geomembrane rolls on pallets or other elevated structures. Do not store geomembrane rolls directly on the ground surface. Do not store more than 3 rolls high.

PART 3 EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any of the work described in this Section, the Contractor shall become thoroughly familiar with all portions of the work falling within this Section.
- B. Inspection:
 - 1. Prior to implementing any of the work in this section, the Contractor shall carefully inspect the installed work of all other sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.
 - 2. If the Contractor has any concerns regarding the installed work of other sections, the Contractor shall immediately notify the Engineer in writing. Failure to inform the Engineer in writing or continuance of installation of the geomembrane will be construed as the Contractor's acceptance of the related work of all other sections.

3.02 SUBGRADE SURFACE PREPARATION

- A. The Contractor shall provide certification in writing that the surface on which the geomembrane will be installed is acceptable. Where other geosynthetics (geogrid) is installed on the subgrade prior to the geomembrane, the Contractor shall inspect the subgrade prior to that geosynthetics (geogrid) installation. This certification of acceptance shall be given to the CQA Consultant prior to commencement of geomembrane installation in the area under consideration.
- B. Special care shall be taken to maintain the prepared surface.
- C. No geomembrane shall be placed onto areas of standing water or hydrated GCL.
- D. Any damage to the GCL or prepared subgrade caused by installation activities shall be repaired at the Contractor's expense.

3.03 GEOMEMBRANE DEPLOYMENT

- A. General:
 - 1. Textured geomembrane shall be used for all liner construction indicated on the Construction drawings.

2. The Contractor shall produce layout drawings prior to geomembrane deployment. These drawings shall indicate the geomembrane configuration, dimensions, details, locations of seams, etc. The layout drawings must be approved by the Engineer prior to the installation of any geomembranes. The layout drawings, as modified and/or approved by the Engineer, shall become part of these Specifications.
3. Do not deploy geomembrane until the layout drawings are approved by the Engineer.
4. Do not deploy a geomembrane panel in an area until the CQA Consultant has been provided with a certificate of subgrade acceptance for that area.
5. Do not deploy geomembranes until CQA Consultant completes conformance evaluation of the geomembrane and performance evaluation of previous work, including evaluation of Contractor's survey results for previous work.
6. Deploy each geomembrane panel in accordance with the approved layout drawings.

B. Field Panel Identification:

1. A geomembrane field panel is a roll or a portion of roll cut in the field.
2. Give each field panel an identification code (number or letter-number). This identification code shall be agreed upon by the CQA Consultant and the Installer.

C. Field Panel Placement:

1. Place each geomembrane panel one at a time and seam each panel immediately after its placement.
2. Use temporary rub sheets as required to prevent displacement or damage to underlying geosynthetics. High spots in geomembrane-backed geosynthetic clay liners shall be covered by a temporary rub sheets during placement of geomembrane.
3. Do not place geomembrane panels when the ambient temperature is below 40° Fahrenheit (F), unless authorized in writing by the Engineer. For cold weather (<40°F) deployment, use the additional procedures authorized in writing by the Engineer.
4. Do not place geomembranes during any precipitation, in the presence of heavy fog or dew, in an area of ponded water, or in the presence of high wind.
5. Ensure that:
 - a. No vehicular traffic drives directly on the geomembrane.
 - b. Equipment used does not damage the geomembrane by handling, trafficking, or leakage of hydrocarbons (i.e., fuels).
 - c. Personnel working on the geomembrane do not smoke, bring glass onto the geomembrane, or engage in other activities that could damage the geomembrane.
 - d. The method used to unroll the panels does not scratch or crimp the geomembrane and does not damage lower geosynthetics and/or the subbase.
 - e. The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels). Adjust or repair any area of geomembrane wrinkles where the wrinkle height, measured perpendicular to the slope during the hottest portion of the day, is more than 4 inches.
 - f. The method used to place the panels does not cause the panels to lift up or trampoline during the coolest portion of the day.

- g. The geomembrane is anchored or weighted with sandbags, or the equivalent, to prevent damage or uplift from wind. Install sufficient anchoring or weighting to prevent uplift and maintain such system until overlying material is placed.
 - 6. Replace any field panel or portion thereof that becomes damaged (torn, twisted, or crimped). Remove from the work area damaged panels or portions of damaged panels.
- D. Do not install geomembrane between one hour before sunset and one hour after sunrise unless approved by the Engineer.

3.04 FIELD SEAMING

- A. Personnel shall be experienced as specified in this Section. Do not perform seaming unless a "master seamer" and the CQA Consultant are on-site.
- B. Orient seams parallel to the line of maximum slope (i.e., oriented down, not across, the slope). Minimize the number of seams in corners and at odd-shaped geometric locations. No horizontal seam shall be less than 10 feet from the toe of the slope, except where approved by the Engineer. Do not locate seams at an area of potential stress concentration.
- C. Weather Conditions for Seaming:
 - 1. Do not seam geomembrane at ambient temperatures below 40°F or above 104°F, unless authorized in writing by the Engineer. For cold (<40°F) or hot (>104°F) weather seaming, use the additional procedures authorized in writing by the Engineer.
 - 2. Measure ambient temperatures between 0 to 6 inches above the geomembrane surface.
 - 3. In all cases the geomembrane seam areas shall be dry and protected from wind.
- D. Overlapping and Temporary Bonding:
 - 1. Sufficiently overlap geomembrane panels for welding and to allow peel tests to be performed on the seam. Any seams that cannot be destructively tested because of insufficient overlap are failing seams.
 - 2. Control the temperature of the air at the nozzle of heat bonding apparatus such that the geomembrane is not damaged.
- E. Seam Preparation:
 - 1. Prior to seaming, clean the seam area and ensure that area to be bonded is free of moisture, dust, dirt, debris of any kind, and foreign material.
 - 2. If seam overlap grinding is required, complete the process according to the Manufacturer's instructions or within 60 minutes of the seaming operation. Do not grind to a depth that exceeds ten percent of the geomembrane thickness. Grinding marks shall not appear beyond 0.25 inch of the extrudate after it is placed.
 - 3. Align seams with the fewest possible number of wrinkles and "fishmouths".

F. General Seaming Requirements:

1. Extend seams to the outside edge of panels to be placed in the anchor trench.
2. If required, place a firm substrate such as a flat board or similar hard surface directly under the seam overlap to achieve proper support.
3. Cut fishmouths or wrinkles at the seam overlaps along the ridge of the wrinkle to achieve a flat overlap. Seam the cut fishmouths or wrinkles and patch any portion where the overlap is less than 6 inches with an oval or round patch of geomembrane that extends a minimum of 6 inches beyond the cut in all directions.
4. Place the electric generator used for power supply to the welding machines outside the area to be lined or mount it on soft tires such that no damage occurs to the geomembrane. Properly ground the electric generator. Place a smooth insulating plate or fabric beneath the hot welding apparatus after use.

G. Seaming Process:

1. Approved processes for field seaming are extrusion welding and fusion welding. The primary method of welding shall be fusion. Seaming equipment shall not damage the geomembrane. Use only Geomembrane Manufacturer-approved equipment.
2. Extrusion Equipment and Procedures:
 - a. Maintain at least one spare operable seaming apparatus on site.
 - b. Equip extrusion welding apparatus with gauges giving the temperature in the apparatus and at the nozzle.
 - c. Prior to beginning a seam, purge the extruder until all heat-degraded extrudate has been removed from the barrel. Whenever the extruder is stopped, purge the barrel of all heat-degraded extrudate.
 - d. Abrade the edges of cross seams to a smooth incline (top and bottom) prior to extrusion welding.
3. Fusion Equipment and Procedures:
 - a. Maintain at least one spare operable seaming apparatus on site.
 - b. Fusion-welding apparatus shall be automated self-propelled devices equipped with gauges giving the applicable temperatures and pressures.
 - c. Fusion-welding apparatus shall produce a double-track seam.

H. Trial Seams:

1. Make trial seams on excess pieces of geomembrane to verify that seaming conditions are adequate. Conduct trial seams on the same material to be installed and under similar field conditions as production seams. Conduct trial seaming at the beginning of each seaming period, and at least once each five hours, for each seaming apparatus used that day prior to seaming. Also, each seamer shall make at least one trial seam each day, for each day that seaming is performed by that seamer. Conduct trial seaming under the same conditions as the actual seaming. Prepare trial seams that are at least 15 feet long by 1 foot wide (after seaming) with the seam centered lengthwise for fusion equipment and at least 3 feet long by 1 foot wide for extrusion equipment. Prepare seam overlap as indicated in the "Overlapping and Temporary Bonding" article of this Part 3.

2. Cut four specimens, each 1.0 inch wide, from the trial seam sample. Test two specimens in shear and two in peel using a field tensiometer. The test specimens shall not fail in the seam. If a specimen fails, repeat the entire operation. If the additional specimen fails, do not accept the seaming apparatus or seamer until the deficiencies are corrected and two consecutive successful trial seams are achieved. A seamer may start production seaming prior to testing of the trial seams. In the event the trial seam fails, all production seams by the seamer are failed seams.

I. Nondestructive Seam Continuity Testing:

1. Nondestructively test field seams for continuity over their full length. Perform continuity testing as the seaming work progresses, not at the completion of field seaming. Complete any required repairs in accordance with the "Defects and Repairs" article of this Part 3. Apply the following procedures:
 - a. Use vacuum testing for extrusion welds; and
 - b. Use air pressure testing for double-track fusion seams.
2. Vacuum Testing:
 - a. Use the following equipment:
 - i. A vacuum box assembly consisting of a stiff housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.
 - ii. A system for applying 5 pound per square inch (psi) gauge suction to the box.
 - iii. A bucket of soapy solution and applicator.
 - b. Follow these procedures:
 - i. Energize the vacuum pump and reduce the tank pressure to 5 ± 1 psi gauge.
 - ii. Wet an area of the geomembrane seam larger than the vacuum box with the soapy solution.
 - iii. Place the box over the wetted area.
 - iv. Close the bleed valve and open the vacuum valve.
 - v. Ensure that a leak tight seal is created.
 - vi. Examine the geomembrane through the viewing window for the presence of soap bubbles for not less than 20 seconds.
 - vii. If no bubbles appear after 20 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 inch overlap, and repeat the process.
 - viii. Mark all areas where soap bubbles appear with a marker that will not damage the geomembrane and repair in accordance with the "Defects and Repairs" article of this Part 3.
3. Air Pressure Testing:
 - a. Use the following equipment:
 - i. An air pump (manual or motor driven) or air reservoir, equipped with a pressure gauge, capable of generating and sustaining a pressure between 25 and 30 pounds per square inch;
 - ii. A rubber hose with fittings and connections; and

- iii. A hollow needle, or other approved pressure feed device.
- b. Follow these procedures:
 - i. Seal both ends of the seam to be tested.
 - ii. Insert needle, or other approved pressure feed device, into the tunnel created by the fusion weld.
 - iii. Insert a protective cushion between the air pump and the geomembrane.
 - iv. Energize the air pump to a pressure between 25 and 30 pounds per square inches, close valve, and sustain the pressure for not less than 5 minutes.
 - v. If loss of pressure exceeds 3 pounds per square inches, or does not stabilize, locate faulty area and repair in accordance with the "Defects and Repairs" article of this Part 3.
 - vi. Cut opposite end of air channel from pressure gauge and observe release of pressure to ensure air channel is not blocked.
 - vii. Remove needle, or other approved pressure feed device, and seal both ends in accordance with the "Defects and Repairs" article of this Part 3.
- J. Destructive Testing:
 - 1. Perform destructive seam tests to evaluate seam strength and integrity. Perform destructive testing as the seaming work progresses, not at the completion of field seaming. Destructive seam test shall meet the seam properties presented in Table 02770-2.
 - 2. Sampling and Testing:
 - a. Collect destructive test samples at a minimum average frequency of one test location per 500 feet of seam length and at additional locations of suspected nonperformance. The CQA Consultant will select test locations, including locations with evidence of excess geomembrane crystallinity, contamination, offset seams, or any other evidence of inadequate seaming.
 - b. Cut samples at the locations designated by the CQA Consultant at the time the locations are designated. Number each sample and identify the sample number and location on the panel layout drawing. Immediately repair all holes in the geomembrane resulting from the destructive seam sampling in accordance with the repair procedures described in the "Defects and Repairs" article of this Part 3. Test the continuity of the new seams in the repaired areas according to "Nondestructive Seam Continuity Testing" article of this Part 3.
 - c. Cut two strips 1 inch wide and 12 inch long with the seam centered parallel to the width from either side of the sample location. Test the two 1-inch wide strips in the field tensiometer in the peel mode. The CQA Consultant may request an additional test in the shear mode. If these samples pass the field test, prepare a laboratory sample at least 1 foot wide by 3.5 feet long with the seam centered lengthwise. Cut the laboratory sample into three parts and distribute as follows:
 - i. One portion 1 foot long to the Installer;
 - ii. One portion 1.5 feet long to the CQC Consultant for testing; and
 - iii. One portion 1 foot long to the Engineer for archival storage.
 - 3. In the event of failing field or laboratory test results, the Contractor may reconstruct the entire seam between two passing destructive tests; otherwise, the CQA

Consultant will identify the extent of the nonconforming area following the procedures given in the CQA Plan. Obtain additional samples for testing as requested by the CQA Consultant.

K. Defects and Repairs:

1. Inspect the geomembrane before and after seaming for evidence of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection. Sweep or wash the geomembrane surface if surface contamination inhibits inspection.
2. Test each suspect location, both in seam and non-seam areas, using the methods described in the "Nondestructive Seam Continuity Testing" article of this Part 3. Repair each location that fails nondestructive testing.
3. Cut and re-seam wrinkles not conforming with this Section. Test the seams thus produced like any other seam.
4. Repair Procedures:
 - a. Repair any portion of the geomembrane exhibiting a flaw or failing a destructive or nondestructive test. Use the most appropriate of the available procedures:
 - i. Patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;
 - ii. Abrading and re-seaming, used to repair small sections of extruded seams;
 - iii. Spot seaming, used to repair minor, localized flaws;
 - iv. Capping, used to repair long lengths of failed seams;
 - v. Topping, used to repair areas of inadequate seams, which have an exposed edge less than 4 inches in length; and
 - vi. Removing bad seam and replacing with a strip of new material seamed into place (used with long lengths of fusion seams).
 - b. When making repairs, satisfy the following:
 - i. Abrade surfaces of the geomembrane that are to be repaired no more than 60 minutes prior to the repair;
 - ii. Clean and dry all geomembrane surfaces immediately prior to repair;
 - iii. Only use approved seaming equipment;
 - iv. Extend patches or caps at least 6 inches beyond the edge of the defect, and round corners of patches to a radius of at least 3 inches; and
 - v. Cut the geomembrane below large caps to avoid potential for water or gas collection between the two sheets.
5. Repair Verification:
 - a. Test each repair using the methods described in the "Nondestructive Seam Continuity Testing" article of this Part 3. Repairs that pass the nondestructive test are adequate unless the CQA Consultant elects to also perform destructive tests. Re-repair and retest failed tests.

3.05 ANCHORAGE SYSTEM

- A. The anchor trench shall be excavated prior to geomembrane placement to the lines, grades, and configuration indicated on the Construction Drawings.
- B. Slightly rounded corners shall be provided in the trench where the geomembrane adjoins the trench to avoid sharp bends in the geomembrane.
- C. Temporarily anchor each geomembrane panel in the anchor trench at the crest of the slope as soon as the panel is deployed or positioned.
- D. Do not entrap loose soil, sandbags, or other materials between or beneath the geosynthetic layers.
- E. Do not backfill the anchor trench until all geosynthetic layers are installed in the anchor trench. Backfill in accordance with the Construction Drawings and Section 02215.
- F. Do not damage any geosynthetic layer when backfilling the anchor trench.

3.06 MATERIALS IN CONTACT WITH THE GEOMEMBRANE

- A. Take all necessary precautions to prevent damage to the geomembrane during the installation of other components of the liner and final cover system.
- B. Do not drive equipment directly on the geomembrane. Only use equipment above the geomembrane that meets the following ground pressure requirements.

Maximum Allowable Equipment Ground Pressure (pounds per square inches)	Minimum Thickness of Overlying Material (inches)
<5	12
<10	18
<20	24
>20	36

3.07 SURVEY CONTROL

- A. Survey the installed geomembrane liner in accordance with Section 02100.

3.08 GEOMEMBRANE ACCEPTANCE

- A. The Contractor shall retain all ownership and responsibility for the geomembrane until accepted by the Owner.
- B. The geomembrane shall be accepted by the Owner when:
 - 1. Installation is finished;

2. All documentation of installation is completed including the CQA Consultant's final report; and
3. Verification of the adequacy of all field seams and repairs, including associated testing, is complete.

3.09 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all prior work and all materials and completed work of other sections.
- B. In the event of damage, the Contractor shall make all repairs and replacements necessary at no additional cost to Owner.

TABLE 02770-1

REQUIRED 60-mil HDPE GEOMEMBRANE PROPERTIES

Properties ⁽²⁾	Qualifiers	Units ⁽¹⁾	Specified Values Textured	Test Method
<u>Physical Properties</u>				
Thickness ⁽³⁾	Nominal	mils	60	ASTM D 5994
	Minimum Avg	mils	57	
Asperity Height	Minimum Avg	mils	16	ASTM D 7466
Density	Minimum	g/cc	0.94	ASTM D 792 or D 1505
Carbon Black Content	Range	%	2-3	ASTM D 4218
Carbon Black Dispersion	N/A	--	9 of 10 in Category 1 or 2 and all in Category 1, 2, or 3	ASTM D 5596
<u>Mechanical Properties</u>				
Tensile Properties				
1. Tensile Strength at Yield	Minimum	lb/in	126	ASTM D 6693 (Type IV)
2. Tensile Strength at Break	Minimum	lb/in	90	ASTM D 6693 (Type IV)
3. Elongation at Yield	Minimum	%	12	ASTM D 6693 (Type IV)
4. Elongation at Break	Minimum	%	100	ASTM D 6693 (Type IV)
Tear Resistance	Minimum	lb	42	ASTM D 1004 Die C Puncture
Puncture Resistance	Minimum	lb	90	ASTM D 4833

TABLE 02770-1 (continued)

Properties	Qualifiers	Units ⁽¹⁾	Specified Values Textured	Test Method
<u>Environmental Properties</u>				
Stress Crack Resistance	Minimum	hrs	500 ⁴	ASTM D 5397 (Appendix)
Oxidative Induction Time (OIT)	Minimum	min	100 / 400	ASTM D 3895 / D 5885

Notes:

- % = percent
hrs = hours
min = minutes
lb = pound
in = inch
g = gram
cc = cubic centimeter
N/A = Not Applicable
- See Paragraph 2.03 for required MQC test frequencies.
- Lowest individual thickness for 8 out of 10 values shall be 54 mils. Lowest individual thickness for any of 10 the values shall be 51 mils.
- For textured geomembrane, test is conducted on the smooth edge of the roll or smooth geomembrane from the same resin lot (batch) as the textured geomembrane furnished.

TABLE 02770-2
REQUIRED 60-mil HDPE GEOMEMBRANE SEAM PROPERTIES

Properties	Qualifiers	Units ⁽³⁾	Specified Values ⁽⁴⁾ Smooth or Textured	Test Method
<u>Shear Strength</u> ⁽¹⁾				
Fusion	Minimum	lb/in (%)	120 (95)	ASTM D 6392
Extrusion	Minimum	lb/in (%)	120 (95)	ASTM D 6392
<u>Peel Strength</u>				
			FTB ⁽²⁾	
Fusion	Minimum	lb/in (%)	91 (72)	ASTM D 6392
Extrusion	Minimum	lb/in (%)	78 (62)	ASTM D 6392

Notes:

- Also called "Bonded Seam Strength". Value is at material yield point and failure shall occur in material outside of seam area.
- FTB = Film Tear Bond. (Maximum 10 percent seam separation).
- lb/in = pounds per inch. % = Percent of the specified minimum yield strength for the geomembrane.
- Values listed for peel and shear strengths are for 4 out of 5 test specimen. The seam strength of the 5th specimen can be as low as 80% of the listed values.

[END OF SECTION]

SECTION 02790

INTERFACE FRICTION CONFORMANCE TESTING

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The work in this section includes all labor, materials, tools and equipment necessary to perform conformance interface shear strength testing using a composite configuration (i.e., “sandwich” test) for the cap liner system. The composite configuration for the cap liner system shall consist of the following components, from top to bottom:
 - 1. Gravel cover layer;
 - 2. Non-woven geotextile;
 - 3. Sandy soil drainage layer;
 - 4. Geocomposite drainage layer
 - 5. HDPE textured geomembrane; and
 - 6. Leveling layer soil.
- B. The Contractor shall be responsible for providing a bucket of representative soil and the required geosynthetics samples to the CQA Consultant for testing 21 days prior to installation of the geosynthetics. The CQA Consultant shall perform the test. One “sandwich” test shall be performed for each CAMU cell.
- C. The CQA Consultant may evaluate the interface shear strength test by testing each interface individually in lieu of the “sandwich” test. If each interface is tested individually, one test shall be performed for each interface for each CAMU cell.

1.02 QUALITY CONTROL

- A. The Materials Testing Laboratory performing the interface friction angle conformance testing shall be accredited by the Geosynthetics Accreditation Institute.
- B. The Materials Testing Laboratory shall perform the required interface friction angle testing in accordance with the American Society for Testing and Materials (ASTM) method D5321 and/or ASTM D6243.
- C. The Materials Testing Laboratory shall provide test results to the CQA Consultant. Test results shall be in the form of figures that present shear force versus displacement

and shear stress versus normal stress. Both peak strength and large displacement (i.e., residual) strength shall be plotted. The laboratory shall report any influences or conditions that may have affected the test results. The laboratory shall indicate the correlation coefficient of the best-fit lines drawn through the strength data and the resulting peak strength and residual strength values for adhesion and friction angle.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Materials to be tested shall be obtained from materials that will be used during construction.
- B. Sample size shall be determined by the Materials Testing Laboratory requirements.
- C. Soil components used in the laboratory testing program shall be obtained from the borrow source to be utilized in the construction of the soil components of the CAMU.
- D. Additional tests may be required at the discretion of the Engineer.

2.02 TEST CONDITIONS

- A. The following testing conditions shall be utilized for the “sandwich” interface friction testing.
 - 1. Use twelve (12) inch by twelve (12) inch square direct shear apparatus as defined by ASTM D5321;
 - 2. Use site-specific soils and materials;
 - 3. Test all geosynthetics in the direction parallel to the length of the roll (i.e., machine direction);
 - 4. Orient surface texturing of the HDPE textured geomembrane so that machine direction is oriented parallel to the direction of movement of the testing apparatus;
 - 5. Soil components shall be remolded and compacted into the testing apparatus at the minimum dry density and maximum moisture content permitted by the relevant Specification Sections;
 - 6. The composite configuration, normal pressures, and strain rate for the interface shear strength test shall be as indicated in the table below;
 - 7. Test results will be used to develop a failure envelope; and
 - 8. All tests shall be run out to a minimum of three (3) inches of horizontal displacement. The large displacement (residual) strengths shall be defined as the strength occurring at the point that shear stress levels off to a constant value or the shear stress at three (3) inches of horizontal displacement, whichever occurs first.

System Analyzed	Composite Configuration (Sandwich Test)	Normal Stresses (psf)	Displacement Rate (inch/min)
Cap Liner System	Gravel Soil Cover Layer Geocomposite Drainage Geomembrane Leveling Soil Layer	2,000 5,000 10,000	0.04

PART 3 EXECUTION

3.01 INTERFACE STRENGTH REQUIREMENTS

- A. The peak interface shear strength envelope for the “sandwich” shall equal or exceed an envelope characterized by an effective friction angle of 25° assuming no adhesion when measured in accordance with the ASTM D5321 or ASTM D6243.

3.02 REVIEW OF TEST RESULTS

- A. The Engineer shall review all test reports to determine if the test results meet the minimum requirements stated above.

3.03 RE-TESTING

- A. The Contractor, Geosynthetics Subcontractor or the Manufacturer may elect to retest failed tests. Testing may be done at the same laboratory or another independent laboratory. The CQA Consultant shall approve the testing laboratory and the testing conditions shall be in accordance with ASTM D5321 and this Section. Re-testing shall be done at the Contractor’s or Manufacturer’s expense. Re-test results shall also be reviewed by the Engineer.

[END OF SECTION]